American Journal of Sciences and Engineering Research

E-ISSN -2348 – 703X, Volume 6, Issue 4, 2023

Open Access

Evaluating Maize Cob Foliar Fertiliser Type and Application Frequency on Maize Growth, and Yield Under Rain-Fed Conditions of Zimbabwe

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ABSTRACT: *The judicious and optimum use of foliar fertilisers enhances and promotes key crop physiological processes that translate to improved crop productivity. An on-farm field experiment was conducted at Portelete Estate in Makonde District, Mashonaland West province of Zimbabwe, to evaluate the effects of maize cob foliar fertiliser type and application frequency on maize growth, and yield under rain-fed conditions. The study was carried out as a 2 × 4 factorial experiment, laid out in a randomized complete block design (RCBD) with three replications. Factor 1 was maize cob foliar fertiliser type (soaked cob leachate (SCL): 1.4 % K and cob ash leachate (CAL): 0.16 % K. Factor 2 was frequency of application of the cob leachates during the growth cycle of the maize crop; viz (1) Control, (2) once at 4 weeks after crop emergence (WACE); (3) twice at 4 and 6 WACE and (4) thrice at 4, 6 and 8 WACE. Nitrogen content was 0.02 % in soaked cob leachate and 0.04 % in cob ash leachate while the phosphorus content was 0.01 % in soaked cob leachate and 0.02 % in the cob ash leachate. Leaf length, flag leaf height, gross biological yield, stover yield, cob mass, grain yield, shelling percentage and maize grain gross revenue were significantly affected ($P < 0.05$) by the frequency of application of maize cob foliar fertiliser. Application frequency of maize cob foliar fertilisers increased gross biological yield, stover yield, cob mass, maize grain yield and gross revenue by 1.9, 2.7, 2.3 and 1.4 times, respectively. The interaction of cob leachate type x application frequency had an effect ($P < 0.05$) on leaf length and flag leaf height. Single application of cob ash leachate foliar fertiliser at 4 WACE, increased maize leaf length and flag leaf height by 36.7 % and 97 cm, when compared to the control treatment. It is, therefore; recommended that maximum utilization of maize cob foliar fertilisers should be advocated in maize production in order to increase maize stover yield, grain yield and grain revenue. It is also recommended that further studies using different maize varieties should be carried to determine NPK and other chemical composition of cobs from other varieties. There is also a need to evaluate the response of different crop species to foliar applications of cob leachates. It is further recommended that single foliar application of the cob leachates at 4 WACE is optimum for obtaining good results in maize production.*

Keywords: *Foliar fertiliser, cob ash leachate, soaked cob leachate.*

 Received-08-07-2023, Accepted- 22-07-2023

I. INTRODUCTION

Maize is the third most widely produced cereal crop after rice and wheat in Africa [1]. Approximately one billion tonnes of the crop are produced per annum in over 170 countries on over 180 million hectares worldwide [2]. The crop is a staple food for an average of 1.2 billion people across the world as well as important as animal feed [3-4]. Consumption requirements per capita are estimated at 110 kg per annum and therefore, giving a total global consumption requirement of around 1.6 million tonnes for a human population of 16 million [5]. A further 350,000 tonnes of maize grain is required to meet an annual requirement for livestock feed [6]. Globally, the human population is ever increasing, and this is associated with a continual increase in food and feed requirement. Poor soil fertility particularly low in phosphorus and potassium, is among the production constraints limiting maize production in small holder farmers in Africa [7].

Maize is used in a variety of ways including livestock feed as well as raw materials for industries [8]. The crop accounts for 30−50 % of low-income household expenditures in Eastern and Southern Africa [9]. Maize grain contains high levels of starch, oils, proteins, calcium, potassium, zinc, iron, selenium, manganese and magnesium [10]. The consumption of maize reduces diabetes and hypertension while, antioxidants in maize improve eye health [11-12].

Maize does well under different climatic conditions [13-14]. Its optimum temperature ranges between 21 °C and 27 °C. It requires 450 to 600 mm of rainfall per season [15]. Soil requirements for the crop production range from sand to clay, but farmers need to pay attention to high nutrient management when it is grown in marginal areas for maximum profit. Maize also tolerate acidic conditions, but a pH of above 5.0 is ideal and soil analysis results are the best determinants for nutrient regime [16].

Both macronutrients and micronutrients applications are essential for increasing maize grain yield and for nitrogen, yield benefits are realised with optimum plant population, earliness of sowing, high yield variety, good weed control and adequate soil moisture supply with up to 30 kg grain/kg N being realisable [17]. It is a constituency of molecules like ATP, NADH and NADPH, protein storage, enzymes, nucleic acids, cytochrome and chlorophyll [18-19]. The general recommendation of nitrogen fertiliser application in high yielding maize varieties is 60–150 kg N ha^{-1}[20-21].

Phosphorus is a second important macronutrient in crop production after nitrogen being essential for optimal growth and biomass production. Phosphorus is a catalyst in the conversion of different important biochemical reactions and involved in the capturing and conversion of the sun's energy into a useful compound in plants [22]. Adequate phosphorus stimulates root growth, increases plant resistance to diseases, improves nitrogen fixation, enhance crop quality and promote stem and stalk strength [23].

Potassium (K) is taken up by maize in large quantities just like nitrogen [24]. Potassium is an essential element for physiological processes, activation of enzymes, availability of water, transport assimilation and photosynthesis in crop plants [25-26]. Plants grown on soils with inadequate potassium tend to have reduced number of leaves, individual leaf size and lower photosynthetic action of the crop [27].

Potassium availability reduces the crop water requirement especially during moisture stress conditions [28-29]. A study done by Damon and Rengel (2008) showed that the grain yield increased by enhancing the uptake of K in drought environment. The recommended rate of potassium fertiliser application is in the range of 30–100 kg per hectare, but its application is advocated on the basis of soil analysis [31-32].

Traditionally, soils in Zimbabwe are assumed to have high amount of potassium. However, its availability is found in a slowly available form for plant uptake [33]. This is because most of the potassium fertiliser is thought to be fixed in clay lattices [34]. Approximately 90 to 98 % of total soil potassium is found in unavailable form, but this depends on soil type [35]. Many granitic sandy soils found in communal areas in Zimbabwe contain minerals like feldspars and micas which are rich in potassium, but slowly available for plant uptake [36].

There is high rate of potassium depletion in soils of Sub-Saharan Africa [37]. This is attributed by ever increasing cropping activities, high rate of straw removal from the fields and introduction of new cereal varieties such as rice [38]. Harvesting of these cereal crops, yields important nutrients like nitrogen, potassium and phosphorus from the soil. A research carried out by the Mosaic Company showed that about 12 % of potassium can be lost from the soil per hectare per season when maize harvested as silage [39]. Potassium is also known to be lost through leaching and run off which is often caused by unequal distribution of rain fall and negatively influences yields [40].

Inorganic fertilisers are commonly applied in the soil and this depends on moisture availability [41]. Soil applied inorganic fertilisers also have a negative impact to our environment, acidifying soils and negatively influencing the climatic change through denitrification processes [42]. In addition, soil applied inorganic fertiliser particularly nitrogen and potassium will lead to soil pollution and thereby reducing the biological activities of microorganisms which are very important on nutrient recycling through decomposition [43].

Leaving farm waste like cobs to decompose in landfills will make these decompose anaerobically and release methane a greenhouse gas with 26 times more global warming potential than carbon dioxide [44]. Furthermore, the cost of purchasing inorganic fertiliser particularly NPK is an inhibitory factor in the production of maize. Currently, the cost of 50 kg of compound D is going for approximately $41-00 USD all-inclusive. These costs negatively affect profits margin and food security in Zimbabwe [45].

During the periods of potassium deficiency, maize productivity can be enhanced through the effective utilization of nutrients from agricultural wastes like corn cobs [46]. Usually cobs are normally burned in the field or used as cooking fuels in farms. However, incorporation of maize cobs as a supplementary foliar fertiliser source of potassium means farmers will substantially increase crop productivity and enhance food security [47].

There is need for locally based solutions like the use of maize cob foliar fertilisers in order to increase maize production and enhance food security in smallholder farmers in Zimbabwe. The application of maize cob foliar fertiliser is considered as more suitable as well as economic tool for improving the efficiency of fertilisers as compared to soil application regimes [48]. A study carried by Ali et al., [34] showed that foliar based potassium applications had increased the financial returns as compared to soil applied potassium fertilisers.

Potassium foliar fertiliser from maize cobs was found to increase grain quality in maize and pod quality in okra [49]. Potassium contributes to the process of photosynthesis through its stimulation on the synthesis of chlorophyll [50]. The use of maize cobs as a farm fertiliser solution will help to fix carbon in the soil and also mitigate the effects of climate change [51]. Inorganic fertilisers are only applied for maintenance requirement and not enough to meet all nutrient requirements sustainably [52].

Currently maize production is approximated at 1.4 million tonnes which is far below to meet the required food security forecast, so there is need for the farmers to make use of cheaper and readily available maize cob foliar fertilisers such that the cost of production will be reduced and improve the yield to sustain the country [53]. A research carried out in Nigeria showed that the combination of maize cob foliar fertiliser and urea increased soil properties and yield of okra [54]. Another study carried out by Hatungimana [55] in Rwanda during 2018/2019 growing season to evaluate the effects of liquid and granular fertilisers on maize yield showed that the maize crop yield increased by 3053 kg/ha^{-1} after using liquid and granular fertilisers in equal proportions compared to control. In this study, it was hypothesised that soaked maize cobs and ash leachate application spray as well as their application frequency have an effect on maize growth and yield.

II. MATERIALS AND METHODS

Description of research site

The study was conducted at Portlet Estates (17° 28' 0" S, 30° 4' 59" E) in Makonde District, Mashonaland West province Zimbabwe. The site is in the agro-ecological region II with a mean annual rainfall of 750 to 1050 mm, occurring between November and March each year. The experimental site is also characterized by warm summers and cool winters, with temperatures ranging from 20-27 ºC and 5-19 ºC, respectively (Figure 1). Agricultural activities involve intense maize, tobacco, wheat and barley production as well as intensive livestock production including dairy, poultry, beef and pig production [17]. Soil samples (0–60 cm) were taken before planting and analysed to determine the amount of Nitrogen (N), Phosphorus (P), Potassium Calcium (Ca) and Magnesium (Mg) which was in the soil (Table 2). The site has a gentle north-east facing slope and soils are sandy loams with an average pH of 7.4 (Table 2.)

During the study, the rainfall was erratic and unevenly distributed although the total recorded amount was close to the long-term average. Precipitation started specifically, in late December and rainfall was immediately followed by a 28-day dry spell that stretched into the critical tasselling stage of the test crop.

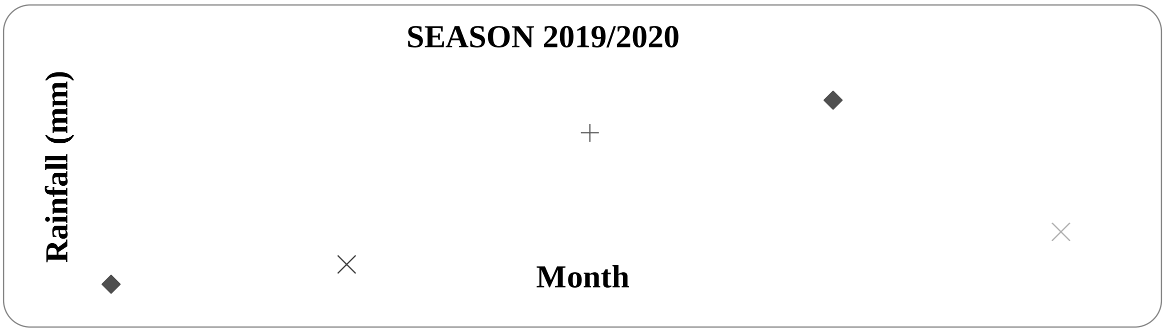

Figure 1 Rainfall distributions during the 2019/2020 cropping season at Portelet Estate (Makonde), Zimbabwe

Preparation of maize cob ash leachate and soaked cob leachate

Harvested, shelled, dried and clean maize cobs from a local hybrid variety SC 727 was collected from commercial farmers around Chinhoyi town in Mashonaland West Province, Zimbabwe. The maize cobs were kept in an open space to allow free circulation of air [34]. One sample of 100 kg of dried maize cob was placed into a 1500 litres drum, two hundred litres of distilled water were added, and the container was sealed using a plastic paper. The maize cobs plus water mixture were then left in the drum for four weeks to allow cobs with enough time to leach out all nutrients into the water. After four weeks, maize cobs were leached out and the extracts were set in a muslin fabric cloth and squeezed thoroughly to produce a clean leachate that would not block sprayer nozzles.

In a separate procedure of preparing cob ash leachate, 100 kg of maize cobs were burnt to ash on a concrete slab under aerobic conditions. All the ashes were collected and placed into a 200-litre drum of boiled tap water. The ash plus water mixture was stored at room temperature (24 ^{o}C), away from sunlight and each 15 litres out of these leachates were strained before use by means of a tea strainer. Both extracts were taken to the laboratory to determine nutrient content.

Chemical composition of soaked cob leachate and cob ash leachate

Two samples of soaked cob leachate and cob ash leachate were put in 2 litre containers each and submitted to Department of Research and Specialist Services in the Ministry of Agriculture, Harare, Zimbabwe for N, P and K content analysis. Nitrogen was analysed using the Kjeldahl methods as well as P and K. The results are as presented in table 2.

Treatments and Experiment design

A total of eight experimental treatments were established (Table 3). The treatments consisted of: Cob ash (CA) applied at 4 levels which was Zero (no application of CA or CAL), CA applied once at 4 weeks after crop emergence (WACE), CA applied twice at (4 and 6 WACE) and CA applied thrice at (4, 6 and 8 WACE), Soaked cob leachate (SCL) applied at 4 levels Zero, SCL applied once at 4 WACE, SCL applied twice at 4 and 6 WACE and SCL applied thrice at 4, 6 and 8 WACE. The criteria followed for selection of the foliar fertilisers' rate and frequency of application was based on the recommendations from the Ministry of Agriculture, Harare, Zimbabwe. The trial was conducted using a 2 × 4 factorial-laid out in Randomized Complete Block Design (RCBD) with three replications. The plots measured 5.0 x 12 m having a gross size plot of 60 m^2 and plant spacing of 0.9 m x 0.25 m within the plot. The blocks and plots were separated by 1 m pathways to eliminate border effects.

Crop establishment and management

The experiment was carried out from December 2019 to May 2020. Land preparation commenced in early November 2019 and was done manually using a hoe at a depth of 0-30 cm. The planting process was done manually 9 days prior to the onset of the rains on 25th December 2019. Basal fertiliser compound D (N_7:P_{14}: K_7) was applied based on the general recommendation of 200 kg ha^{-1} from smallholder sector and incorporated into the soil using a hand hoe before planting, recommendation of Huang et al [13]. A maize variety Zim 51 spaced at 0.9 m x 0.25 m, two maize seeds per hole placed after putting some soil on top of the basal fertiliser. Eight days after crop emergence, the seedlings were then thinned to one plant per station, leaving one healthy plant per station resulting in a population of 44 444 plants per hectare on the gross plot of 60 m^2. Manual weeding was done twice, first at 22 days after planting and the second one was done at 46 days after planting.

Ammonium nitrate (34.5 % N) was applied as top- dressing fertiliser at 3 weeks after emergence as a once off application at the rate of 150 kg ha^{-1} combined with the equal initial application of cob ash and soaked cob leachate at recommended rates. The subsequent doses of cob ash and soaked cob leachate were applied at four, six and eight weeks using the rate of 1.4 % K per hectare. Foliar application activities were done by the use of a graduated 16 litre knapsack spray. Application of prophylactic pesticide treatments was done from two weeks after emergence to prevent cutworm damage and early incidences of fall armyworm.

Application of cob ash and soaked cob leachate foliar fertiliser was applied at prescribed rate of 1.4 % K per hectare firstly, once at 4 WACE, twice at (4 and 6 WACE) and thrice at (4, 6 and 8 WACE) at a speed of 3.2 sec/per plant using a 15 litre knapsack with standard flow rate of 15 mm/sec [21]. According to Mcauliffe [58], the amount of water required per hectare is determined by the concentration of intended foliar fertiliser type. A graduated measuring cylinder was used to measure foliar fertiliser in order to apply equal quantities throughout the 48 plants.

Collection of Agronomic Data

The biophysical data collected included plant height (cm), flag leaf height (cm), leaf length (cm), cob mass (kg ha^{-1}), and grain yield (kg ha^{-1}), stover weight (kg ha^{-1}), shelling percentage, biological yield (kg ha^{-1}), harvest index, gross revenue (USD ha^{-1}) and 1000 grain weight (kg ha^{-1}). All growth and yield measurements were done on 10 randomly selected plants from 1 middle row of each plot.

Data analysis

Genstat Discovery Version 18th Edition statistical package was used to carry out all statistical analysis of variance (ANOVA) (VSN International Ltd., 2015). Tukey's test was carried out to check for the normality, homogeneity, and validity of the data. Least Significant Difference (LSD) at $p \leq 0.05$ was used to separate the means among treatments.

III. RESULTS AND DISCUSSION

Effect of maize cob foliar fertiliser type on maize leaf length

There was a significant interaction ($p<0.05$) between cob ash leachate and application frequency on maize leaf length (Figure 2). For cob ash leachate application frequencies of once at 4 WACE and twice at 4 and 6 WACE increased leaf length by 36.7 % and 36.6 % respectively, compared to the control treatment. In contrast, leaf length was not affected by soaked cob leachate foliar fertiliser at 4, 6 and 8 WACE (Figure 2).

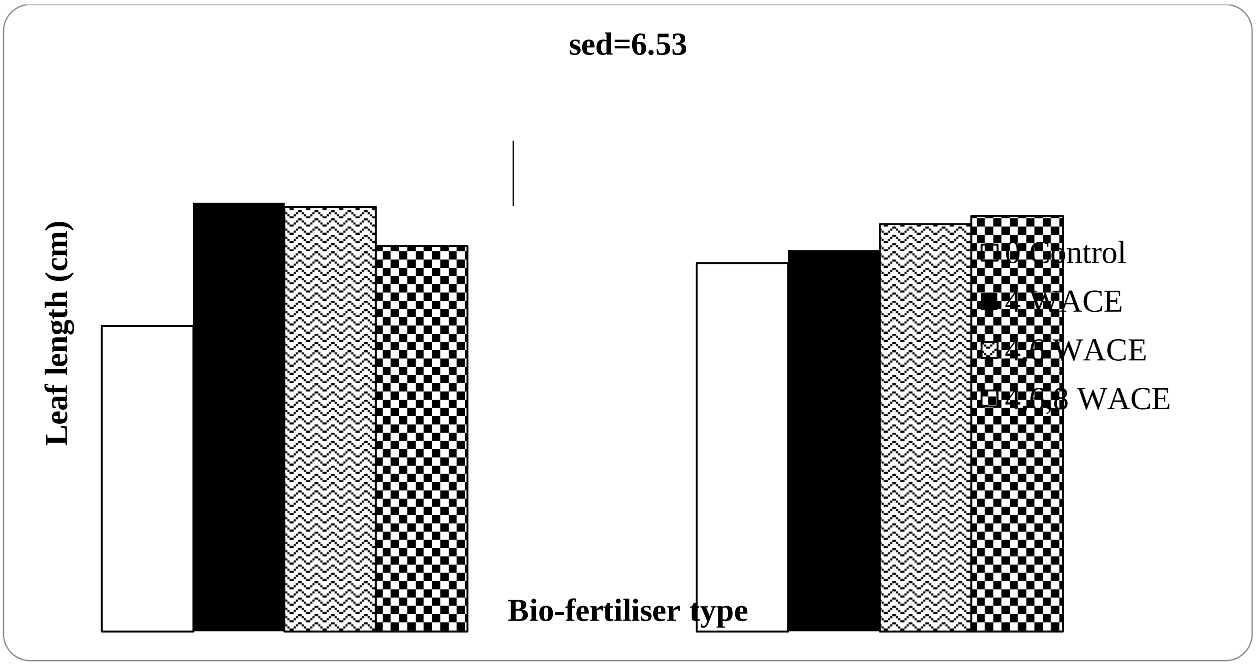

Figure 2 Effects of maize cob foliar fertiliser type and frequency of application on the leaf length during 2019/2020 cropping season, Portelet Estate, Chinhoyi, Zimbabwe

Effects of maize cob foliar fertiliser type and application frequency on maize flag leaf height

There was a significant interaction ($p<0.05$) between cob ash leachate and application frequency on maize flag leaf height (Figure 3). Single application of cob ash leachate at 4 WACE resulted in a greater maize flag leaf height (97 cm) than the control treatment which had (62 cm). These significant effects of application frequency were absent when soaked cob leachates were used at 4, 6 and 8 WACE (Figure 3).

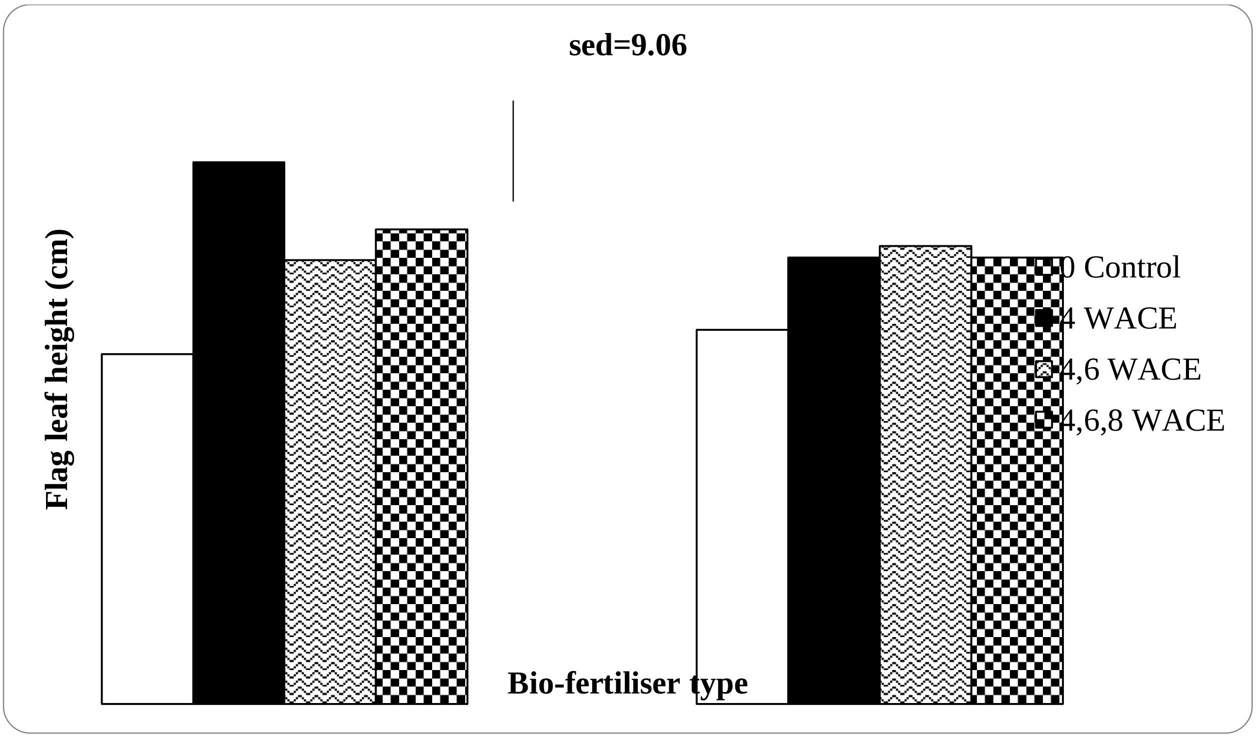

Figure 3 Effects of maize cob foliar fertiliser type and frequency of application on the flag leaf height during 2019/2020 cropping season, Portelet Estate, Chinhoyi, Zimbabw **The effect of maize cob foliar fertiliser type on maize plant height, gross biological yield, stover yield and cob mass**

Application frequency of maize cob foliar fertiliser significantly affected ($p<0.05$) maize gross biological yield, stover yield and cob mass but had no significant effect on maize plant height (Table 4). Two applications (at 4 and 6 WACE) of cob ash and soaked cob leachate increased gross biological yield by 1.9 times, stover yield by 2.7 times and cob mass by 2.3 when compared to the control treatment (Table 4).

The effect of maize cob foliar fertiliser type on 1000 grain weight, shelling percentage, harvest index, maize grain yield and maize gross revenue

The application frequency of maize cob foliar fertiliser had a significant effect ($p<0.05$) on maize grain yield and maize gross revenue but no significant effect ($p>0.05$) on 1000 grain mass, harvest index and shelling percentage at physiological maturity of maize (Table 5). Single application of cob leachate increased grain yield by 1.4 times while gross revenue was increased by 1.4 times compared to control treatment (Table 5). Maize cob foliar fertilisers had no effect ($p>0.05$) on 1000 grain weight, shelling percentage, harvest index, grain yield and gross revenue during the growing season (Table 5).

Effects of maize cob foliar fertiliser type and application frequency on benefit cost ratio

The maize cob foliar fertiliser type had no significant effect ($p>0.05$) on benefit cost ratio, but however, application frequency of maize cob foliar fertiliser significantly affected ($p<0.05$) benefit cost ratio (Table 6). Single application of cob leachate at 4 WACE increased the returns by 0.88 and 1.11 compared to the control treatment and other application frequencies (Table 6).

Potassium fertiliser requirement per hectare

The amount of potassium fertiliser required to fertilise 1 hectare of maize is 60 kg [34]. It means about 0.73 g of potassium can be required to fertilise one plant of maize assuming a population of 44 000 plants per hectare. According to Heuzé et al., [59], 5 g of potassium can be yielded from 1kg of maize cobs. This means we need 12000 tonnes of maize cobs to yield 60 kg of potassium. Profile [60], confirmed that the rate of 1-3 % of potassium can be enough to fertilise 1 hectare of maize when used as foliar fertiliser. So, from the analysis 100 kg of maize cobs leached into a 200-litre of water yielded 1.4 % of potassium and extracted 0.16 % of potassium from 100 kg of burned maize cobs which was then diluted into 200 litres of water.

Maize growth parameters

The significant interaction between cob ash leachate type and application frequency on leaf length and flag leaf height during the growing season, suggest that maize cobs contain some essential nutrients that enhance plant growth. These results are in concurrence with the findings of Oosterhuis [61] who observed that maize cob leachates contained nitrogen and phosphorus in low concentrations and reasonable amounts of potassium (0.16-1.4 %). It can be suggested that the positive response on maize leaf length and flag leaf height as a result of cob leachate application were due to the effects of potassium which increases physiological processes in plant growth.

The results of the present study showed that a single application of cob ash leachate at 4 weeks after crop emergence was enough to increase maize leaf length and flag leaf height. Phenologically, this could be the most critical growth stage which plants can take up more nutrients for their growth. According to Hg et al. [62], early application of nutrients and early planting have great influence on leaf expansion and development as well as overall plant development. Similarly, Hatungimana [55] also observed that early application of foliar fertilisers has positive effects on maize flag leaf height and leaf length. In agreement with the findings of this present study, Adekiya et al. [15] alluded that full uptake of foliar nutrients in okra was at 4 weeks after crop emergence with no effect of further applications on leaf expansion and development. Therefore, it can be suggested that, regarding leaf length and flag leaf height, early application of maize cob foliar fertilisers is mostly beneficial.

Maize yield parameters

Two applications of cob leachates at 4 and 6 weeks after crop emergence increased gross biological yield, stover yield and cob mass by 1.9 to 2.7 times relative to the control treatment. The results of the present study also concur with those of Zhuang et al. [17] who observed that early application of potassium based foliar fertilisers increases all yield parameters in maize. The cob leachates that were used in this study contained reasonable amounts of potassium (K) as shown by laboratory analysis results. Potassium is useful in increasing biochemical reactions in plants and thus results in overall increase in gross biological yield, stover yield and cob mass. In agreement with the findings of this present study, Ocampo [63] observed increased plant biomass when plant wastes were applied as foliar sprays at 4 weeks after crop emergence. The author attributed this to high amount of potash found in these crop residuals.

Application frequency at (4 and 6 WACE) of maize cob foliar fertiliser increased grain yield and gross revenue of maize by 1.4 times and 1.4 times compared to the control. These results agree with the observations of Carlsson et al. [64] who acknowledged that, time of application of potassium based fertiliser is important in influencing grain yield and gross revenue in maize production. The results of the present study also agree with the observations of Ceballos et al. [65] who acknowledged that application of maize cob foliar fertiliser towards physiological maturity increases grain yield and grain revenue in wheat production. The author attributed this to the reasonable amounts of 0.16 to 1.4 % potassium found in maize cobs.

IV. Conclusion

The results of the study showed that soaked cob leachate and cob ash leachate had reasonable amounts of potassium (0.16-1.4 %) and low nitrogen (0.02-0.04 %) and phosphorus (0.01-0.02 %). In agreement with the second hypothesis of this study, judicial and optimum use of soaked cob leachate or cob ash leachate had positive effects on leaf length, flag leaf height, gross biological yield, stover yield, cob mass, grain yield and maize grain gross revenue. Frequency of application of maize cob leachate was only effective on gross biological yield, stover yield, cob mass, grain yield and maize gross revenue.

Acknowledgements — Authors are grateful to thank Marondera University of Agricultural Sciences and Technologies (MUAST). The acknowledgement also extended to Dr Chipomho, Dr Mashavakure, Mr Kagoro and Mr Chaguluka who assisted the authors with all field experimental activities and data collection.

Disclosure statement

The authors declare that they have no conflict of interests.

Table 1 Physical and chemical soil composition properties of the initial sample at Portelet Estate, Makonde, Zimbabwe

Physical and Chemical property Particle size analysis	Value
pH	7.4
Calcium Ca (mg per 100g)	7.92
Magnesium Mg (mg per 100g)	2.34
Potassium (K) (mg per 100g)	0.4
Phosphorus (P)	13
Nitrogen (N)	333
Textural class	Medium grained Sandy Loam
Soil colour	Light brown

Table 2 Laboratory results of soaked cob extract and cob ash extract

Foliar fertiliser type	Nutrient	Analytical results (percentage)
Cob ash leachate	Nitrogen	0.04
	Phosphorus	0.02
	Potassium	0.16
Soaked Cob leachate	Nitrogen	0.02
	Phosphorus	0.01
	Potassium	1.40

Table 3 Treatments that were used in the field experiment during 2019/2020 cropping season at Portelet Estate, Chinhoyi, Zimbabwe

Treatment number	Leachate type	Application frequency (WACE)
1.	Cob ash	Zero (No CA or CAL)
2.		Once at 4 WACE
3.		Twice at (4 and 6 WACE)
4.		Thrice at (4, 6 and 8 WACE)
5.	Soaked cob leachate	Zero (No SCL)
6.		Once at 4 WACE
7.		Twice at (4 and 6 WACE)
8.		Thrice at (4, 6 and 8 WACE)

Table 4 Effects of maize cob foliar fertiliser type and application frequency on plant height, gross biological yield, stover yield and cob mass during the 2019/2020 cropping season at Portelet Estate, Makonde, Zimbabwe

Foliar fertiliser type	Plant Height@9WAP	Gross Biological yield (t ha^{-1})	Stover yield (t ha^{-1})	Cob Mass (t ha^{-1})
1. Cob Ash Leachate	181.6	9.26	4.07	0.93
2. Soaked Cob Leachate	179.8	9.81	4.85	0.85
P Value	**NS**	**NS**	**NS**	**NS**
L S D	15.30	1.152	0.887	0.302
Application Frequency				
Control	166.0	6.30^{c}	2.37^{c}	0.52^{c}
Once at 4 WACE	185.3	11.93^{a}	6.30^{a}	0.89^{bc}
Twice at 4 and 6 WACE	189.3	9.19^{b}	4.15^{b}	0.96^{b}
Thrice at 4, 6 and 8 WACE	182.3	10.74^{b}	5.04^{b}	1.19^{a}
P Value	**NS**	0.001	0.001	0.033
L S D	21.64	1.629	1.255	0.427
Foliar fertiliser type* Application Frequency				
P Value	**NS**	**NS**	**NS**	**NS**

NS -not significant

Means followed by different letters within the same column are significantly different at (P<0.05)

Table 5 Effects of maize cob foliar fertiliser type and application frequency on 1000 grain weight, shelling percentage, harvest index, grain yield and gross revenue during the 2019/2020 cropping season at Portelet Estate, Makonde, Zimbabwe

Foliar fertiliser type	1000 Grain weight	Shelling %	Harvest Index	Grain Yield (t ha^{-1})	Gross revenue (USD ha^{-1})
1. Cob Ash Leachate	270	82.40	0.51	4.26	1277.78
2. Soaked Cob Leachate	278	83.39	0.45	4.11	1233.33
P Value	**NS**	**NS**	**NS**	**NS**	**NS**
L S D	16.9	4.679	0.115	0.633	190.008
Application Frequency					
Control	263	86.69	0.46	3.41^{a}	1022.22^{a}
Once at 4 WACE	287	83.72	0.42	4.74^{b}	1422.22^{b}
Twice at 4 and 6 WACE	273	81.28	0.53	4.07^{ab}	1222.22^{ab}
Thrice at 4, 6and 8 WACE	273	79.88	0.50	4.52^{b}	1355.56^{b}
P Value	**NS**	**NS**	**NS**	0.031	0.031
L S D	23.9	6.617	0.162	0.896	268.712
Foliar fertiliser type* Application Frequency					
P Value	**NS**	**NS**	**NS**	**NS**	**NS**

NS -not significant
Means followed by different letters within the same column are significantly different at (P<0.05)

Table 6 Effects of maize cob foliar fertiliser type and application frequency on benefit cost ratio during the 2019/2020 cropping season at Portelete Estate, Makonde, Zimbabwe

Treatment	Leachate type	Leachate application frequency	Yield (t/h^{-1})	Gross Revenue (US$)/$h^{-1}$	Cost of cultivation (US$)/$h^{-1}$	Net monetary returns (US$)/$h^{-1}$	B.C.R
1	**CA**	**0**	3.41	1022.22	762.23	259.99	0.34^{b}
2	**CA**	**4**	4.74	1422.22	756.22	666.00	0.88^{d}
3	**CA**	**6**	4.07	1222.22	981.99	240.23	0.24^{a}
4	**CA**	**8**	4.52	1355.56	988.22	367.34	0.37^{c}
5	**CL**	**0**	3.41	1022.22	762.23	259.99	0.34^{b}
6	**CL**	**4**	5.33	1599.00	756.22	842.78	1.11^{d}
7	**CL**	**6**	4.11	1233.33	970.30	263.03	0.27^{a}
8	**CL**	**8**	4.26	1464.00	988.22	475.78	0.48^{c}

NS -not significant
Means followed by different letters within the same column are significantly different at (P<0.05)

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