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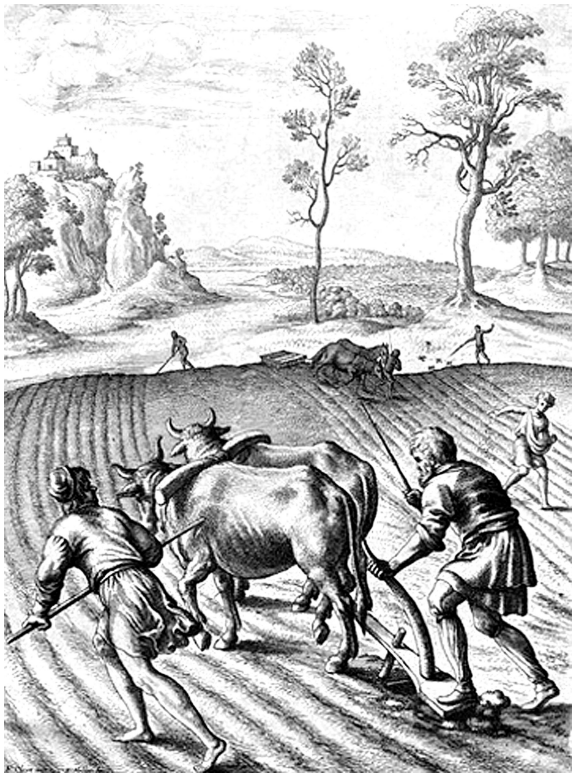

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Effects of Foliar Fertilizer on Yield and Quality of Green Mealies (*Zea mays* L.)

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Abstract: Improvement of yield and quality of green mealies is paramount in green mealies production to guarantee high income for farmers and nourishment for consumers. A study was conducted to determine the effects of rate and time of application of multi-nutrient foliar fertilizer (OmniBoost) on cob length, kernel weight and crude protein content of green mealies in order to enhance income and nourishment from horticultural products. Evaluation was done on potential role of multi-nutrient foliar fertilizers on yield and nutritional quality of green mealies. OmniBoost was applied as a supplementary fertilizer at 4, 6 and 10 Weeks After Crop Emergence (WACE) using 0, 2, 4, 6 and 8 kg ha^{-1}. Time of application had no significant effect on cob length, kernel weight and crude protein content. Rate of application had a significant effect ($p<0.05$) with 4 and 6 kg ha^{-1} giving the highest values for all attributes considered. Time×rate of application interaction was not significant ($p>0.05$). The optimum rate of application was established to be 4 kg ha^{-1}. Increment of 2 kg ha^{-1} and doubling this rate resulted in no significant increase in attributes considered and it is not economic. Farmers may not apply beyond 4 kg ha^{-1} OmniBoost under similar crop production conditions in order to optimise yield, quality and income. Application of multi-nutrient foliar fertilizer may therefore be a practical consideration to enhance yield, quality and income from horticultural products.

Key words: Multi-nutrient foliar fertilizers, green mealies, cob length, kernel weight, crude protein, nutritional quality, yield

INTRODUCTION

Green mealies are consumed as a snack; either roasted or boiled and are a rich source of carbohydrates. Green mealies also contain fat, proteins and fiber which is a valuable part of human diet because it forms an indigestible bulk against which the muscles of the intestines can exercise and so retain their healthy tone (Hamilton and Whitney, 1980). In Zimbabwe, green mealies production is a horticultural enterprise and market prices are not controlled by the government as is the case with maize, the staple food crop. Some smallholder farmers grow maize in the irrigation schemes during the off-season and they get a good price for the green mealies (Goebel, 2005). The price depends largely on the size of the cob, nutritional quality and time of supply. Bigger cobs fetch high prices on the market (Anonymous vegetable vendor, personal communication). The size of the cob is fixed genetically and it is a complex genetic trait. It took maize farmers several thousand years to select new varieties with increasingly larger cob sizes (Murphy, 2011). It is therefore important to manage the crop in order to exploit full potential of the plant. One way is to manage fertilizer application during the production process.

Soil fertility and plant nutritional factors set the limit for crop productivity. It is important that fertilizer application in green mealies be centred on the adequacy of the level of nutrients to give bigger cobs of high nutritional quality. Fertilizers allow farmers to raise soil fertility so that yields of crops are not limited by the amount of plant nutrients that the natural system can supply (Cooke, 1982). Soil applied fertilizers are subject to leaching, fixation or volatilization. This suggests that the presence of a nutrient in the soil, either from inherent conditions or from applied fertilizers, does not ensure that a plant will assimilate it. Likewise, the presence and

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availability of the nutrient element at the start of the growing season does not assure its presence and availability for plant uptake throughout the growth process. Plant nutrients applied early in plant growth may be lost or become unavailable before the crop requirements are met (Chikowo *et al*., 2004). The extent to which maize roots explore the soil and capture nitrogen depends on the soil profile and root length density (Van Noordwi, 1989). Spot application of nitrogen fertilizers after crop emergence may not necessarily result in increased fertilizer recovery because of maize spatial root length density distribution (Van Noordwi, 1989). The method and timing of fertilizer application is an essential component of good farming that enhances good yields. Spot applied or side dressed fertilizers are not likely to have much immediate effect due to delayed nutrient release (Mtambanengwe and Kosina, 2007) In view of those problems, application of foliar fertilizers in addition to soil applied fertilizers ensures nutrients availability hence increased plant growth and yield.

Application of a combination of OmniBoost and Folifert Molibor at 0.5 kg ha^{-1} and 0.5 L ha^{-1}, respectively, increased soybean (*Glycine max* (L.) Merril) grain yield (Nyabadza, 2007). A combination of OmniBoost and Kelp-P-max solution increased barley (*Hordeum vulgare* L.) grain yield by 0.5 t ha^{-1} and increased proportion of large tubers in potatoes (*Solanum tuberosum*) (Omnia Nutriology, 2004). Therefore, the use of multi-nutrient foliar fertilizer in green mealies can be a good toner which can result in yield increase, considering that its application has increased yields in crops such as barley, potatoes, citrus and pineapples (Omnia Nutriology, 2004). Improved yields and quality of green mealies can enhance income for farmers. The objectives of this study were to determine the effects of application of multi-nutrient foliar fertilizer on cob length, kernel weight and nutritional quality of green mealies and to determine possible interaction between timing of application and application rate.

MATERIALS AND METHODS

Study site: The study was carried out for two years during the rainy seasons of 2005/2006 and 2006/2007 farming season at The University of Zimbabwe, Department of Crop Science in Harare. The site is characterised by red fersiallitic soils with more than 30% clay (Nyamapfene, 1991). The site is about 1500 m above sea level and receives total rainfall in the range of 750-1000 mm annum^{-1}.

Treatments and experimental design: The experiment was set up as a 5×3 factorial with the treatments arranged in a Completely Randomized Design (CRD) with three replicates. The test crop was maize cultivar, PAN 6234. Factor A was rate of application of OmniBoost (multi-nutrient foliar fertilizer) with five levels (0, 2, 4, 6 and 8 kg ha^{-1}). Factor B was time of application of Omniboost with three levels (4, 6 and 10 WACE). The control was non foliar-fertilized.

PAN 6234 is a maize cultivar which takes on average 100 days to horticultural maturity (Pannar Seeds, 2006). OmniBoost is a solid, multi-nutrient water-soluble supplementary foliar fertilizer recommended for application in maize at 4 to 6 WACE. It contains 7.7% N, 39.6% P_2O_5, 4.2% S, 3.1% Mg, 0.35% Fe, 0.004% Cu, 0.092% Mn, 0.004% Zn and 0.008% Mo (Omnia Specialities, 2006). The gross and net plot sizes were 3.6×3.6 m and 1.8×x 2.0 m, respectively.

Crop management and observations: The crop was hand sown at 0.9×0.25 m, giving a plant population of about 44 444 plants ha^{-1}. Basal fertilizer Compound D (7% N: 14% P_2O_5: 8% K_2O+min 8% S) and top dressing fertilizer Ammonium nitrate (34.5%) were applied by spot placement at 400 and 150 kg ha^{-1}, respectively. OmniBoost was applied as a supplementary fertilizer using a knapsack sprayer and leaf scotching was observed where 8 kg ha^{-1} was applied. The Kjeidahl method was used for the analysis of crude protein. All the data was subjected to analysis of variance using GENSTAT and means were separated using Least Significant Difference (LSD) where $p<0.05$.

RESULTS

Cob length: Foliar fertilizer application rate significantly ($p<0.05$) influenced cob length (Table 1). The longest cobs i.e., 25.02 cm were obtained when 6 kg ha^{-1} OmniBoost was applied and this length was not significantly different from 24.99 cm which was obtained

Table 1: Effect of foliar fertilizer rate, timing of application and their interaction on cob length (cm)

	Time of ppplication			
Application rates (kg ha^{-1})	4 WACE	6 WACE	10 WACE	Means
0	23.57	23.54	23.54	23.54^{c}
2	24.96	24.70	24.71	24.79^{ab}
4	25.16	24.99	24.81	24.99^{a}
6	25.28	24.69	25.08	25.02^{a}
8	24.42	24.42	23.54	24.13^{bc}
Means	24.66	24.47	24.34	
		p-value		$LSD_{0.05}$
Effects of application rate		0.006*		0.868
Effects of time of application		0.596		ns
Rate×time of application		0.979		ns
CV%		3.7		

Means followed by different letters in a column are significantly different at $p<0.05$. ns: Not significant, *significant at $p<0.05$

Table 2: Effect of foliar fertilizer rate, timing of application and their interaction on kernel weight (g)

Application rates (kg ha^{-1})	Time of application			
	4 WACE	6 WACE	10 WACE	Means
0	265.0	265.0	265.0	265.00^{bc}
2	296.0	280.0	276.0	284.00^{b}
4	341.0	316.0	310.0	322.33^{a}
6	321.0	316.0	299.0	312.00^{a}
8	286.0	230.0	261.0	259.00^{c}
Means	301.8	281.4	282.2	
		p-value		$LSD_{0.05}$
Effects of application rate		0.001**		19.435
Effects of time of application		0.73		ns
Rate×time of application		0.0628		ns
CV%		6.88		

Means followed by different letters in a column are significantly different at p<0.05. ns: Not significant, **significant at p<0.01

Table 3: Effect of foliar fertilizer rate, timing of application and their interaction on crude protein content of green mealies (%)

Application rates (kg ha^{-1})	Time of application			
	4 WACE	6 WACE	10 WACE	Means
0	7.620	7.620	7.620	7.6^{b}
2	7.973	7.547	7.743	7.8^{ab}
4	8.277	7.583	8.157	8.0^{a}
6	7.770	7.423	7.797	7.7^{ab}
8	6.880	6.880	7.097	6.9^{c}
Means	7.704	7.411	7.683	
		p-value		$LSD_{0.05}$
Effects of application rate		0.001**		0.3615
Effects of time of application		0.74		ns
Rate×time of application		0.786		ns
CV%		4.9		

Means followed by different letters in a column are significantly different at p<0.05. ns: Not significant, **significant at p<0.01

when 4 kg ha^{-1} OmniBoost was applied. Application of 6 kg ha^{-1} OmniBoost increased cob length by 1.48 cm relative to non-foliar fertilizer applied treatment (control). Timing of fertilizer application and rate×time of application interaction had no significant (p>0.05) effect on cob length.

Kernel weight: Foliar fertilizer application rate had a significant effect (p<0.05) on kernel weight (Table 2). Highest weight of kernels per cob was obtained when 4 kg ha^{-1} OmniBoost was applied and this weight was comparable to the obtained when 6 kg ha^{-1} OmniBoost was applied. The control (0 kg ha^{-1}), low rate (2 kg ha^{-1}) and high rate (8 kg ha^{-1}) resulted in low weight of kernels. An increase of 45 and 49 g was detected when 4 kg ha^{-1} was applied relative to non-foliar applied treatment (0 kg ha^{-1}) and high rate of application (8 kg ha^{-1}), respectively. Timing of fertilizer application and rate x time of application interaction had no significant (p>0.05) effect on kernel weight.

Crude protein: Foliar fertilizer application rate had a significant effect (p<0.05) on crude protein of green mealies (Table 3). The highest level of crude protein was recorded when 4 kg ha^{-1} OmniBoost was applied and this was comparable to when 2 and 6 kg ha^{-1} OmniBoost were applied. High rate (8 kg ha^{-1}) recorded the lowest crude protein level and resulted in a decrease of 1.1 and 0.7 units relative to when 4 kg ha^{-1} OmniBoost was applied and the control, respectively. Timing of fertilizer application and rate×time of application interaction had no significant (p>0.05) effect on crude protein of green mealies.

DISCUSSION

The control and low rate of OmniBoost application (2 kg ha^{-1}) resulted in shorter cobs compared to 4 and 6 kg ha^{-1} treatments, probably due to reduced supply and availability of plant nutrients. This also concurs with findings by Selvaraju and Iruthayaraj (1994). The increase in length of cobs and number of grains per cob with increased fertilizer application could be attributed to adequate nutrient supply which in turn improved all growth and yield influencing characters i.e., the increased physiological processes in crop plants leading to higher growth and increased photosynthates to silks. This might be due to better utilization of plant nutrients supply (Selvaraju and Iruthayaraj, 1994). Kumar *et al.* (2007) also observed differences in cob length per plant with different levels of fertilizer application. The treatment which received high doses of plant nutrients recorded the highest cob length and the treatment which received the lowest dose of nutrients recorded lowest cob length (Kumar *et al*., 2007). However, in this study application of OmniBoost at 8 kg ha^{-1} resulted in reduced length of the cobs probably due to leaf scotching that was exhibited, thus reducing the leaf area that may have resulted in reduction in photosynthetic rate and efficiency. Lack of significant difference in cob length between application of 4 and 6 kg ha^{-1} OmniBoost suggest that there was luxury consumption of plant nutrients by applying 6 kg ha^{-1}. This also indicates that there is no benefit to the farmer by applying more fertilizer (6 kg ha^{-1}) since the results are the same as for applying 4 kg ha^{-1}. Application of 6 kg ha^{-1} OmniBoost is not economic and may result in reduced income.

Application of OmniBoost increased kernel weight by 60 g relative to non-foliar fertilizer applied treatment suggesting that availability of plant nutrients enhanced plant productivity. Low kernel weight at 2 kg ha^{-1} could be due to reduced supply and availability of plant nutrients as explain for cob length. Low kernel weight at 8 kg ha^{-1} could be due to the scotching effect that reduced the photosynthetic area and subsequent photosynthetic rate and efficiency of the plant. Photosynthesis is the most important source of weight for

grain yield during the grain filling period (Gardner *et al*., 1985). This could explain the low kernel weight where 8 kg ha^{-1} OmniBoost was applied.

Low crude protein content in green mealies where no foliar fertilizer was applied could be due to limited levels of available nitrogen. Nitrogen is an integrated part of the chlorophyll molecule and it plays a role in the formation of proteins (Tisdale *et al*., 2002). High crude protein levels in treatments where 4 and 6 kg ha^{-1} were applied could be due to adequate supply and availability of nitrogen. Nitrogen is a mobile nutrient and very prone to leaching, hence application of foliar fertilizer could have provided a more rapid utilization of the nutrient and permits correction of deficiencies in less time than would be required by soil treatment (Tisdale *et al*., 2002). Soil application of nutrients does not usually relieve deficiencies and so spraying directly on the foliage is usually effective (Arnon, 1975). Foliar application of plant nutrients is particularly useful under conditions where the nutrient uptake from the soil is restricted (Jolly, 1993). In this study, if soil applied nitrogen had been lost or restricted, then, application of foliar fertilizer probably corrected the deficiencies and enhanced plant growth and physiological processes in the plant and subsequent increased photosynthates to the grain to increase crude protein. Hence, higher crude protein content at 4 and 6 kg ha^{-1}. The lowest crude protein content in green mealies recorded at 8 kg ha^{-1} could be due to toxicity caused by the high levels of nutrients affecting the physiological processed of the plant. Also, the reduced leaf area due to leaf scotching may have caused the low crude protein levels.

Time of application of foliar fertilizer did not have any significant benefit on cob length, kernel weight and crude protein of green mealies and no interaction was found between time and rate of application. This indicate that nutrient demand, if met at any time within the period studied (4-10 WACE), would result in similar yield and nutritional quality benefit.

CONCLUSION

Based on the results of this study, it was concluded that foliar application of OmniBoost significantly improved cob length, kernel weight and crude protein content of green mealies and not more than 4 kg ha^{-1} OmniBoost would be required under the same crop production conditions. Therefore, it can be recommended that farmers use the established optimum rate, 4 kg ha^{-1} OmniBoost as a supplementary foliar fertilizer to enhance income in green mealies production.

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