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Nutrient Content of Vegetable Amaranth (*Amaranths cruentus* L.) at Different Harvesting Stages

N.D. Makobo, M.D. Shoko and T.A. Mtaita

Faculty of Agriculture and Natural Resources, Africa University, P.O. Box 1320, Mutare-Zimbabwe

Abstract: Data on the nutritional content of conventional vegetables can be reasonably associated with a specific stage of plant development, but information about the age of plant development to define harvest maturity for wild or indigenous leafy vegetables including amaranths is scanty. A field experiment was conducted in order to assess the, P, K, Ca, Na, Cu and Zn content at different harvest stages of amaranth. Amaranths were harvested at 3, 4, 5, 6, 7 and 8 weeks after emergence (WAE). A significant difference ($P<0.05$) was observed in the time these different mineral nutrients reached highest levels. At 3 WAE Ca and Zn, at 4 WAE P, at 6 WAE K and at 7 WAE Na and Cu reached their highest levels. Protein level significantly decreased from 50.8 to 43.47% during the 8 weeks. Regardless of the differences in reaching their highest levels which stretched from 3 to 7 WAE, it was observed that when Ca and Zn reached their highest level at 3 WAE, other minerals despite being low in their concentration could still meet the Daily Required Allowance (DRA) for humans.

Keywords: Amaranth · Harvesting stage · Foliar nutrients

INTRODUCTION

The maturity stage of a conventional vegetable is universally defined and a crop is normally harvested and consumed at a known stage of plant development, irrespective of environmental conditions for plant growth [1]. Unlike conventional vegetables, there is no documented information about the age of plant development to define harvest maturity for wild or indigenous leafy vegetables including amaranths. Hence data on their nutritional value is likely to vary widely, due to influences of plant age and the environmental conditions during plant growth [2, 5].

Since the nutritional content of amaranths is affected by the age of the plant, the objective of this study was to assess the foliar nutritional content of amaranth at the different harvesting stage.

MATERIALS AND METHODS

Experimental Site: The study was carried out at the Africa University farm in the 2008-2009 farming season. The farm lies in Natural Farming Region II of Zimbabwe, at 18°53.595 S and 32°36.173 E, at an altitude of 1104 m above sea level. The mean annual rainfall is about 800-1000 mm. The soils are red sandy clay loam, Fersiallitic 5E soil under Zimbabwe soil classification system [3].

Experimental Design and Treatments: The experiment was laid in Randomised Complete Block Design (RCBD) and was replicated three times. The treatments comprised six harvest stages at 3, 4, 5, 6, 7 and 8 weeks after emergence (WAE). At each harvest stage four different processing methods which include fresh harvested leaves used as control, dry leaves without any pre-treatment, blanched dry leaves and blanched frozen leaves were carried out.

Land Preparation and Crop Establishment: The area was ploughed and then disked. The gross plot was 6 m^2 and the net plot was 2.16 m^2. Seeds were drilled in furrows of 1.0cm deep on January 08, 2009. Rows were spaced 30 cm apart and the space between plants was 15 cm. The distance between blocks was 1m and the distance from the edges of the research block was 1m on each side. Rainfall was the major source of water, but irrigation was also applied whenever necessary. To maintain the plots weed free, hand pulling and shallow cultivation were carried out.

Corresponding Author: N.D. Makobo, Faculty of Agriculture and Natural Resources, Africa University, P.O. Box 1320, Mutare-Zimbabwe, E-mail: shokom@africau.ac.zw or davidmakobo@yahoo.fr

Economic Yield: After measuring the biological yield, the edible parts which included tender stems and leaves were separated from the rest of the stem. The edible parts were also weighed in order to get the economic yield.

Foliar Nutrient Analyses: The harvested materials were analysed for Phosphorus, Potassium, Calcium, Sodium, Zinc and Copper using the wet oxidation method and protein was analysed using the MicroKjedahl [4].

Statistical Analyses: Statistical analysis was done using Genstat version 8.0

RESULTS AND DISCUSSION

Nutrient Levels at Different Harvest Stages: There were significant ($p<0.05$) difference in the level of each mineral nutrient and protein among harvest stages. The highest amount of calcium (2693.1 mg 100 g^{-1}) was observed at 3WAE. The 3rd WAE had 89% more Ca than at 8 WAE. With the observed 2693.1 mg 100 g^{-1} even if the amaranth is cooked, the daily required allowance (DRA) of 1000 to 1300 mg/day will still be met [5]. This suggests that most calcium accumulation in Amaranth happens within the first three weeks after emergence. The highest level of Ca (2693.1mg 100 g^{-1}) which was observed at 3rd wk compares favorably to (2683 mg 100 g^{-1}) reported in *Amaranthus spinosus* Contrary to the results observed, Marschner [7] reported a Ca level of 44.15 mg 100 g^{-1} in *Amaranthus hybridus*. The differences in calcium levels can be attributed to the differences in climatic conditions and cultivars.

The highest Cu concentration (23.27 mg 100 g^{-1}) was observed at 7 WAE. At 7 WAE, amaranth had 73% and 88% more Cu than at 3 and 8 WAE, respectively.

Significant difference ($P<0.05$) were observed in the level of K at different harvest stages. The highest level of K was reached at 6 WAE (29341 mg 100 g^{-1}). At 6 WAE, K was 40 and 66 % more than at 3 and 8 WAE, respectively. The observed level of potassium ranging from 835.7 mg 100 g^{-1} to 2934.1 mg 100 g^{-1} is greater than 54.20 mg 100 g^{-1} which was reported by Marschner [7]. The differences in K levels could be attributed to the cultivar or climatic condition. With the observed values of 2934.1 mg 100 g^{-1} even if losses in K are incurred as a result of cooking, it will meet the DRA of 3500 mg/day [5].

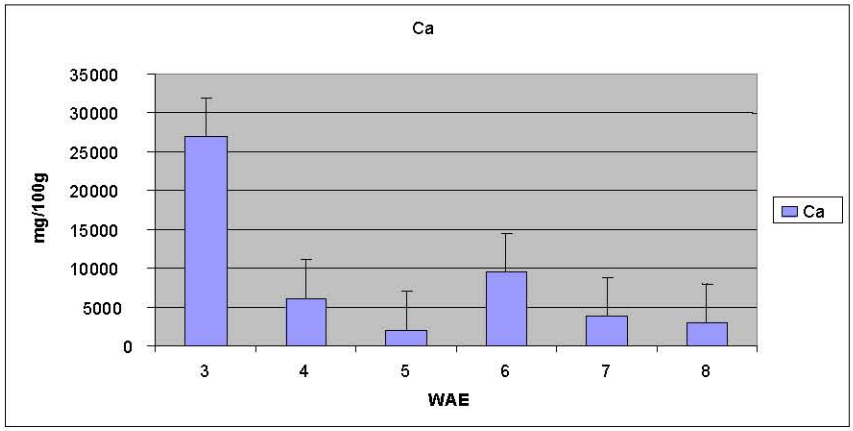

Fig. 1: Mean Ca content (mg 100 g^{-1}) of *Amaranthus cruentus* for the six harvest stages

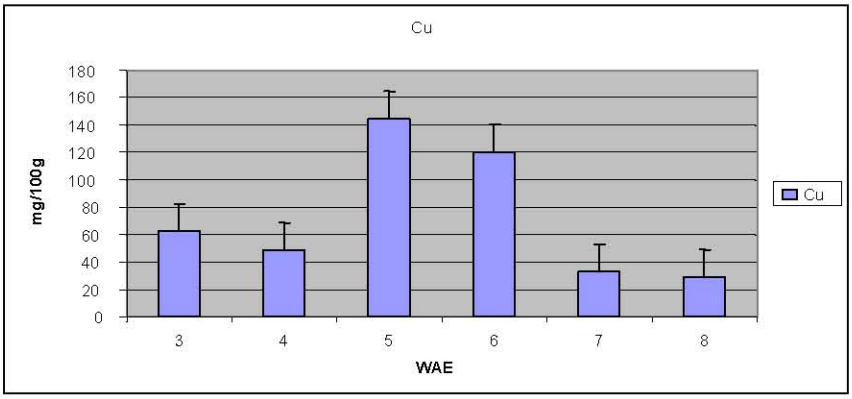

Fig. 2: Mean Cu content (mg 100 g^{-1}) of *Amaranthus cruentus* for the six harvest stages

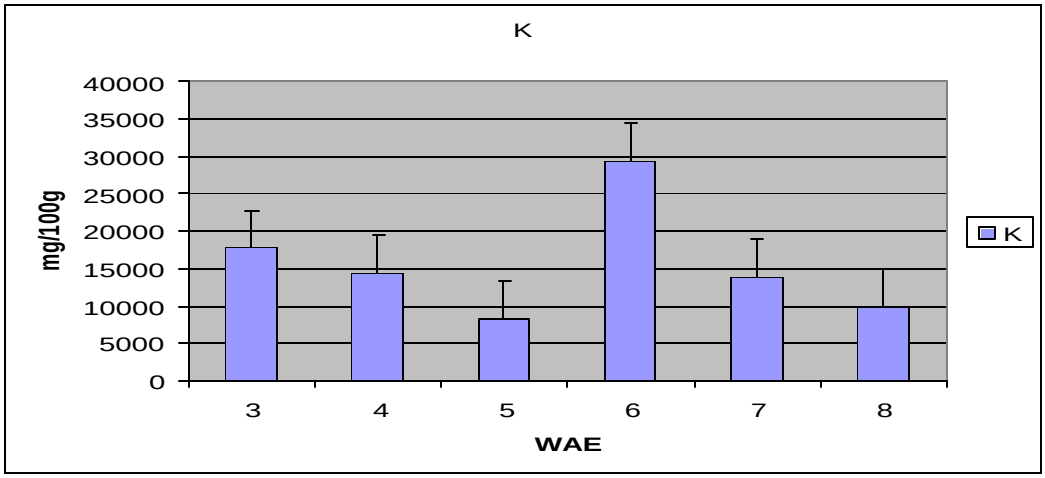

Fig. 3: Mean K content (mg 100 g^{-1}) of *Amaranthus cruentus* for the six harvest stages

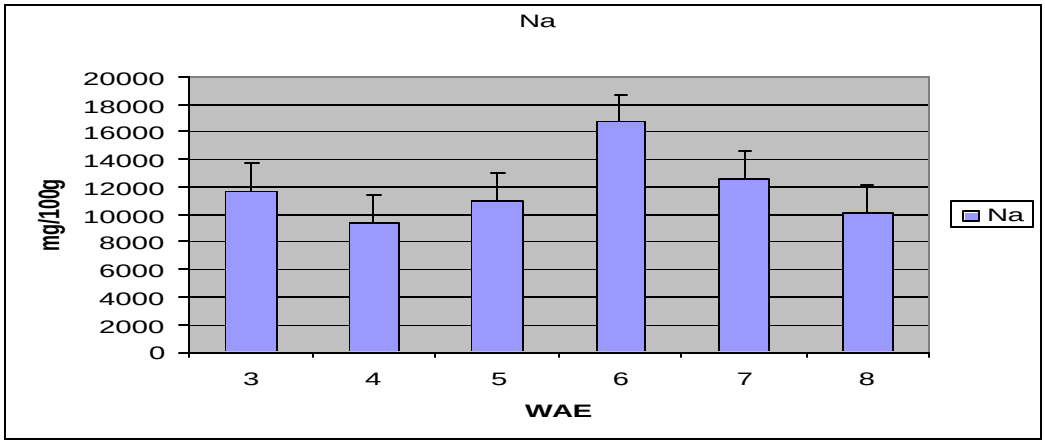

Fig. 4: Mean Na content (mg 100 g^{-1}) of *Amaranthus cruentus* at six harvest stages

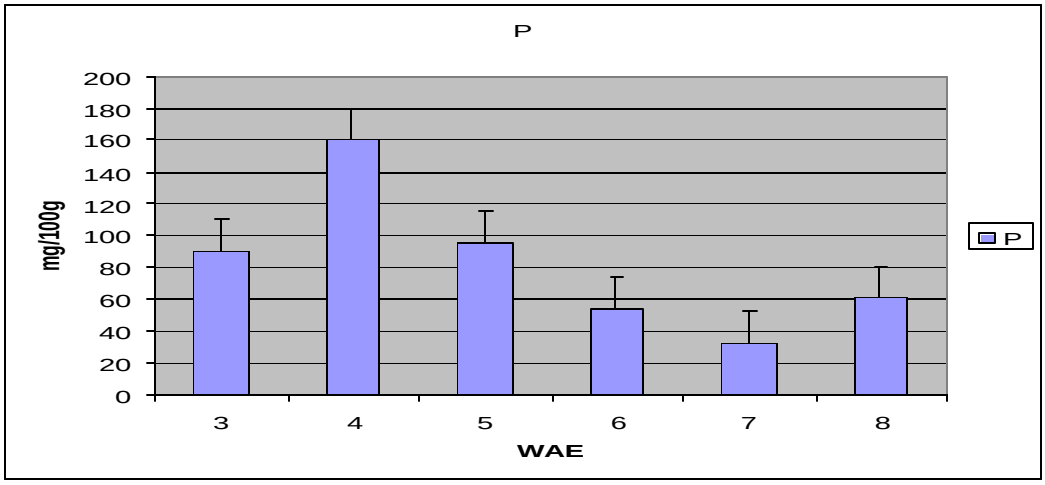

Fig. 5: Mean P content (mg 100 g^{-1}) of *Amaranthus cruentus* for the six harvest stages

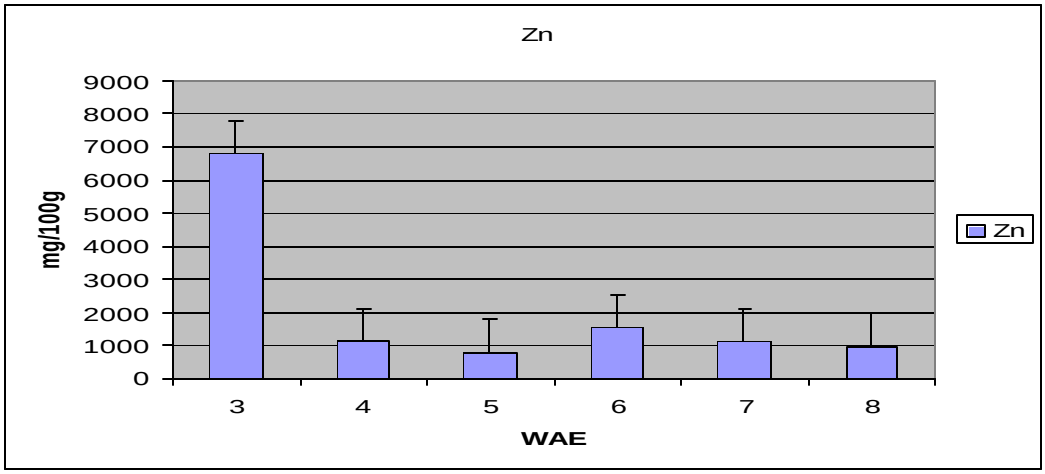

Fig. 6: Mean Zn content (mg 100 g^{-1}) of *Amaranthus cruentus* for the six harvest stages

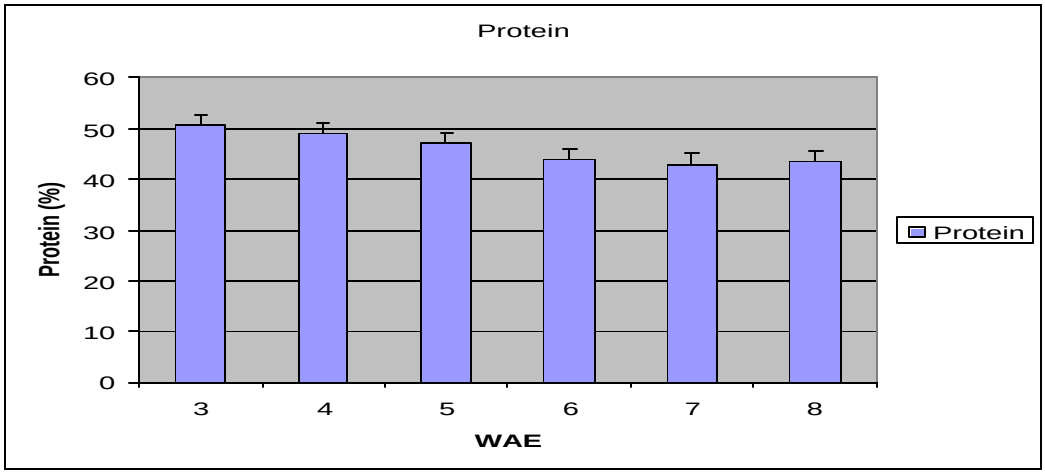

Fig.: 7 Mean protein (%) of Amaranthus cruentus for the six harvest stages

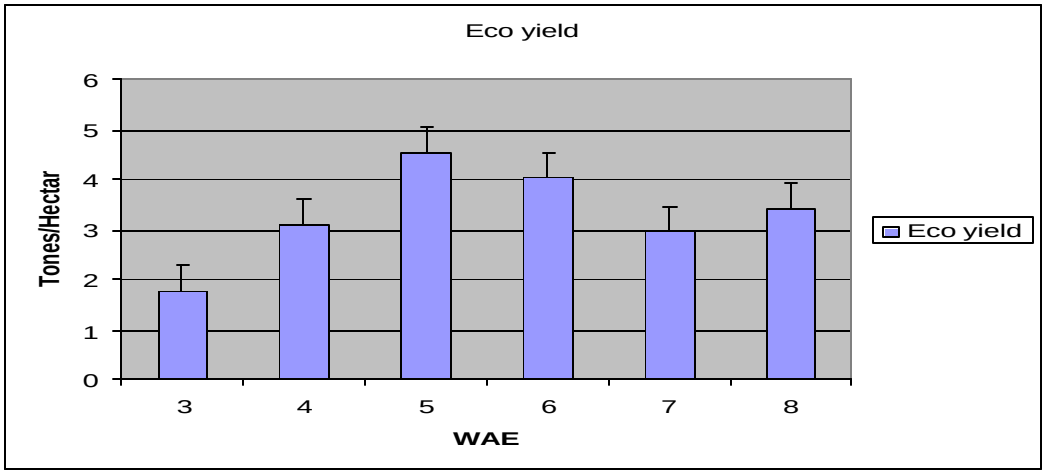

Fig. 8: Mean economic yield (t ha^{-1}) of fresh mass at the six harvest stages.

This implies that the optimum level of potassium in amaranth is obtained when it is harvested at 6 WAE. According to Marschner [7] the level of potassium is expected to decrease with the increase in age. This could be due to the partitioning of photosynthetic products which with age is directed to the reproductive growth.

The highest Na level was at 6 WAE (16732 mg 100 g^{-1}). Sodium level of 934.9 to 1673.2 mg 100 g^{-1} found is higher than 7.43 mg 100 g^{-1} which was noted in work done by Akubugwo et al [6]. The DRA of Na is 2000 to 2400mg/day [5]. When cooking amaranth salt is usually added and 5 grams salt (about a tea spoon) is equated to 2 g/2000 mg which will meet the DRA of sodium [5].

As shown in Fig. 5 significant differences ($P<0.05$) in P concentration at different harvest stages. The highest P concentration of 160 mg 100 g^{-1} was reached at 4WAE. At 4WAE P was 44 and 80% more than at 3 and 8WAE, respectively. The DRA of P of 700mg/day is not fully met by simply consuming the amaranths, but food additives can contribute as much as 30% of dietary phosphorus [5].The highest concentration (6789 mg 100 g^{-1}) was observed at 3WAE. The level of Zn at 3WAE was 85% more than at 8th WAE.

Results show significant differences ($P< 0.05$) in the protein level amongst different harvest stages. The protein content level decreased from 50.8 to 43.47% during the 8 weeks. There were no significant differences from 3 to 5 WAE and from 6 to 8 WAE. The highest protein level (50%) observed at 3WAE is 12% higher than the highest level (38.3%) reported by Oliveria and De Carvalho [8].

Economic Yield: There were significant differences ($P<0.05$) in the economic yield among the different harvest dates. The highest economic yield was noted at 6 WAE (4.56 t ha^{-1}) and the lowest was 1.78 t ha^{-1} at 3 WAE. At 6 WAE the economic yield was 141 % higher than that at 3 WAE. The highest economic yield was attained at 6WAE. This would suggest that after 6WAE, partitioning of dry matter was directed towards inedible plant parts thus the biological yield continued to increase while economic yield remained constant.

CONCLUSION

Under the Africa university conditions, it has been observed that different minerals in amaranth reached their highest levels at different growth stages. If the amaranth is grown to meet the nutritional requirement for a particular mineral nutrient or protein, then it should be harvested at the stage when it reaches its highest level for that particular mineral nutrient or protein. On the other hand, if the grown amaranth is to meet the nutritional requirements for different minerals (P, K, Ca, Na, Cu and Zn), the optimum time to harvest will be at 3 WAE. From the results of this study it is true that only Ca and Zn will have reached their highest level at 3 WAE, but P, K, Na and Cu at this stage will be in quantities that can still meet the daily required intake (DRI).

ACKNOWLEDGEMENTS

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