Effect of Seasonal Irrigation on Nitrogen and Crude Protein Content of Enset \{*Ensete ventricosum* (Welw.) Cheesman\}

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The effect of seasonal irrigation on nitrogen and crude protein composition of *Ensete ventricosum* (Welw.) Cheesman was quantified under field condition. The experiment was conducted at Gubre (8° 19.9’ N and 37° 48.3’E), Southern Ethiopia, during the dry season. A total of 108 individual plants of two enset clones, locally known as yeshirakinke (YK) and nechwa (NH) were selected randomly from three age classes (summa-2 yrs, hiba- 4 yrs and ässät- 6 yrs, old) with three replicated plots. Treatment constituted irrigating half of the randomly selected experimental plants every other day to the field capacity of the soil for 75 days whereas the rest were exposed to seasonal drought. Crude protein (CP) and total nitrogen content (TN) were investigated. The results revealed that TN and CP contents did not show significant differences between irrigated and droughted plants indicating that enset plant tolerates seasonal drought stress. Implications of the findings to drought research in enset and the promotion of the crop to drought prone areas is discussed in the paper.

Key words: Enset, Protein, Nitrogen, Chlorophyll, relative water content and clone

INTRODUCTION

Enset \{(*Ensete ventricosum* (Syn. *Musa ensete* Gmel.; *Musa ventricosa* Welw.; *Ensete edule* Horan.; fibre banana, wild banana, Abyssinian banana, Ethiopian banana, false banana (English) (Weldemichael Kelcha, 1987)) is a multipurpose crop that is used for food, fiber, medicine, wrapping, storage, and livestock feed. The major foods obtained from enset are carbohydrate rich foods locally known as kocho (baked, similar to bread), bulla (porridge from the flour) and amicho (boiled corn). All sorts of enset foods are usually consumed with milk and milk products, vegetables and other protein rich foods as enset has very small amount of protein content (Taye, 1984). Enset is a safeguard tree to peasants in the face of adverse environmental conditions. Researchers have indicated that systematic investigation of all aspects of enset production received very little attention in the past (Seifu, 1993; Brandt, *et al.* 1997; Almaz, 2001). The researches that have been conducted in the past mainly focused on propagation techniques and spacing of plants in the farm (Mulugeta Diro *et al.*, 1993); yield analysis (Hiebsch, 1993); germplasm collection; socio-economics and manure application (Lee and McCabe, 1996). So far there has been very little research on the ecophysiology of enset and its response to different environmental stress conditions, such as water deficit stress. The extent of water deficit impact on the physiology and nutritional composition of enset has not been investigated so far (Brandt, *et al.* 1997). In this study, the effect of drought on nitrogen and crude protein content of enset at different age classes was investigated with the aim of identifying useful traits and clonal differences for the selection of drought tolerance.

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MATERIALS AND METHODS

Description of the Study Site

The experiment was conducted at Gubre (8°19.9' N and 37°48.3' E), Southern Nations Nationalities and Peoples Regional State (SNNPRS), Gurage zone, located some 175 km southwest of Addis Ababa. The average annual temperature and rainfall of the area is 20.6°C and 164 mm respectively. During the study period, only 10 mm of rainfall/month was recorded. The altitude of the area is 1885 m asl.

Experimental Plants

Two clones of enset, locally known as yeshirakinke (YK) and nechwa (NH), at three age classes were used for this study. Enset farmers in the study area give names to different classes of enset. Accordingly, two, four and six years old ensets are locally known as summa, hiba and ässät respectively were selected for the study.

Experimental Design and Growing Condition

The experimental design was a completely randomized design (CRD) with sub-sampling in which replications of treatments were assigned at random and each experimental plant was considered as a single independent experimental unit. Two enset clones each at summa, hiba and ässät stage, each of which contained eighteen individual plants in each of three plots, were used for the study under field irrigation and seasonal drought condition. The irrigation treatment was applied in every other day to the field capacity of the soil by supplying water manually.

Physical and Chemical Analysis of Soil

Soil pH was determined by immersing pH meter in water suspension of the soil samples (1:1) (Sahlemedhin and Taye, 2000). Total nitrogen was determined following the macro Kjeldahl method (Sahlemedhin and Taye, 2000). The organic matter of the soil is roughly estimated from the total nitrogen content of the soil by multiplying the percent total nitrogen by 20 (Sahlemedhin and Taye, 2000).

% Organic matter= % total nitrogen × 20

Soil organic carbon was determined from the total nitrogen by multiplying the total nitrogen by 11.6 (Sahlemedhin and Taye, 2000). % Organic carbon= % total nitrogen × 11.6. Total nitrogen was determined following the Kjeldahl method as described before. From the percentage of the total nitrogen, crude protein was determined by multiplying the nitrogen percentage by 6.25 assuming that all the nitrogen was found as protein in the plants as most plant proteins contain 16% nitrogen.

Statistical Analysis

All collected data were subjected to statistical analysis using SPSS statistical package version 16. One-way analysis of variance test was used to identify the significance of the variation (P≤0.05). Specifically, LSD test was used for morphological parameters and Bonferroni test was used.

RESULTS

Soil Analysis

The pH is slightly alkaline in all plots, with values ranging from 7.53 to 8.56. The total nitrogen percentage ranged from 0.64 to 1.3% and the percentage of organic matter ranged from 16% to 26% whereas the percentage of organic carbon ranged from 9.28 to 15.08%. The variation observed between the plots was not significant at 95% level of significance; hence, it was assumed that the plots had more or less similar soil composition with respect to the parameters analyzed.

Total Nitrogen

The percentage of total nitrogen contained in different plant parts: Corm (C), pseudostem (PS), and leaf (L), of the two experimental enset clones is shown in Table 1. In the corm total nitrogen content increased with increasing age of ensets in YK plants. Similarly, the clone NH contained highest total nitrogen at hiba stage and lowest in summa stage. Droughted plants contained less total nitrogen than the irrigated plants at hiba and summa stage in the clone YK. The nitrogen content of the PS also varies among age classes (ACs), clones and treatments. Under irrigated condition, YK plants contained least amount of nitrogen in the summa stage and highest amount in the ässät stage. On the other hand, NH plants contained highest amount of nitrogen at hiba stage and least amount in the summa stage. Unlike YK, the clone NH had similar nitrogen content in the irrigated and droughted condition. At summa and ässät stage, YK had higher nitrogen content than NH in the corresponding ACs in the irrigated condition and vice versa for droughted condition. YK irrigated plants at ässät stage had higher nitrogen content than droughted plants at the same AC.

The percentage of nitrogen in the leaf (PNL) did not
show much variation among ACs, treatments and clones compared with that of in the PS. In YK, summa ACs had higher nitrogen content than the rest ACs in the irrigated condition. Unlike YK, NH contained higher nitrogen in the ässät stage than the rest ACs in the irrigated treatment and vice versa in the droughted condition. YK had higher nitrogen content at summa stage than NH in the same AC under irrigated condition.

Generally, the variation observed in total nitrogen content of two clones of enset in different plant parts and ACs was not significant even though there were few significant differences that support the null hypothesis. Therefore, there is no any sufficient evidence either to reject or to accept the null hypothesis.

Crude Protein

The percentage of crude protein contained in the corm (C), pseudostem (PS), and leaf (L) of two enset clones is shown in Table 2. The percentage of protein in the corm increased with increasing ACs in the clone NH under irrigated condition. In the clone YK, ässät plants contained the highest amount of crude protein and plants at hiba stage contained the least amount. Droughted plants had lower amount in both clones. Like the irrigated plants, the percentage of crude protein increased with increasing age classes under droughted condition in the clone NH with significant difference. At ässät stage, droughted plants of YK contained lower crude protein than irrigated plants but the difference is insignificant.

The percentage of crude protein in the PS showed insignificant difference between ACs though there is little variation. YK plants at summa stage contained higher crude protein than the other ACs in both treatments and there is a decreasing trend of protein under droughted condition than the irrigated ones though the difference is insignificant. In NH plants there was no similar trend in all ACs when the protein content was compared between treatments.

Leaves contained much amount of crude protein than the C and PS in all treatments, ACs and clones. When the percentage difference is compared within ACs, it is highly significant (p=0.000). As the age of ensets increased, the protein content also increased in all ACs, treatments and clones. The NH and YK plants contained similar protein content in the corresponding ACs with very little difference.

**Table 1.** Percentage of total nitrogen in the corm (C), pseudostem (PS), and leaf (L) of three age classes of two clones of enset

<table>
<thead>
<tr>
<th>Clone</th>
<th>Age</th>
<th>Treatment</th>
<th>C</th>
<th>PS</th>
<th>L</th>
<th>C</th>
<th>PS</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Irrigated</td>
<td>0.26 ± 0.03a</td>
<td>0.25 ± 0.05eb</td>
<td>1.82± 0.06d</td>
<td>0.25 ± 0.03eb</td>
<td>2.10±0.11a</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.55 ±0.04</td>
<td>0.58 ± 0.06eb</td>
<td>2.06± 0.11a</td>
<td>0.42 ± 0.02a</td>
<td>0.19 ± 0.3EBd</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YK</td>
<td>0.18 ± 0.67a</td>
<td>0.26 ± .08</td>
<td>1.52 ± 0.11a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>0.46 ± 0.03a</td>
<td>0.25 ± 0.05eb</td>
<td>1.82± 0.06d</td>
<td>0.17±0.03a</td>
<td>0.25 ± 0.03eb</td>
<td>2.10±0.11a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>0.54 ± 0.04a</td>
<td>0.58 ± 0.06eb</td>
<td>2.06± 0.11a</td>
<td>0.42 ± 0.02a</td>
<td>0.19 ± 0.3EBd</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.27 ± 0.04a</td>
<td>0.14 ±0.01Eb</td>
<td>2.07± 0.08a</td>
<td>0.52±0.05a</td>
<td>0.18 ± 0.3EB</td>
<td>1.89 ± 0.12a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH</td>
<td>0.75 ±0.04a</td>
<td>0.41 ± 0.01a</td>
<td>2.02± 0.13a</td>
<td>0.60 ± 0.06a</td>
<td>0.44 ± .06a</td>
<td>1.91 ± 0.03a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>0.71 ± 0.06a</td>
<td>0.23±0.04abc</td>
<td>2.14± 0.18a</td>
<td>0.88 ± 0.08a</td>
<td>0.66± 18EBCD</td>
<td>1.49 ± 0.59a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means followed by the same lower case and upper cases have significant differences within the same plant part.

S= summa, H= hiba, E= ässät.

**Table 2.** Percentage of crude protein in the corm (C), pseudostem (PS), and leaf (L) of three age classes of two clones of enset

<table>
<thead>
<tr>
<th>Clone</th>
<th>Age</th>
<th>Treatment</th>
<th>C</th>
<th>PS</th>
<th>L</th>
<th>C</th>
<th>PS</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Irrigated</td>
<td>2.0 ± 0.24b</td>
<td>3.6 ± 0.06a</td>
<td>9.6 ± 0.42a</td>
<td>1.0 ±0.11b</td>
<td>2.1 ± 0.64a</td>
<td>9.6 ± 0.59a</td>
</tr>
<tr>
<td>YK</td>
<td>1.8 ± 0.05b</td>
<td>1.9 ± 0.12a</td>
<td>14.3 ± 0.59a</td>
<td>1.1 ± 0.12b</td>
<td>1.8 ± 0.12a</td>
<td>13.0 ± 0.93a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>3.3 ±0.13BLNT</td>
<td>3.2 ± 0.18a</td>
<td>14.5±0.30a</td>
<td>2.8 ±0.11BnQGHij</td>
<td>1.8 ± 0.58a</td>
<td>12.7 ± 0.81a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH</td>
<td>4.8 ±0.36BDig</td>
<td>3.0 ± 0.60a</td>
<td>14.6 ± 0.59a</td>
<td>4.7 ±0.52BErgth</td>
<td>2.5 ± 0.12a</td>
<td>13.0 ± 0.48a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>5.0 ± 0.14BIE</td>
<td>1.4 ± 0.31a</td>
<td>14.5 ± 0.27a</td>
<td>4.3 ± 0.24BEJ</td>
<td>2.4 ± 0.16a</td>
<td>9.4 ± 0.41a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means followed by the same lower case and upper case differ significantly within the same plant part, P< 0.05.

S= Summa, H= Hiva, E= Esset.
Generally, the results indicated that water stress affects the protein content of enset in the corm with significant difference in some ACs. With respect to the protein content of PS and L, there is no significant difference between treatments and ACs; hence, there is no sufficient evidence to reject the null hypothesis.

DISCUSSION

Total nitrogen and crude protein content in the corm increased with increasing age of ensets in YK plants and there was a trend of decreasing nitrogen content in the droughted plants than the irrigated plants. Levitt (1980) described that dehydration of plant cells resulted in hydrolysis of proteins and the effect of dehydration on protein breakdown is rapid. In addition, in Zea mays, free amino acids increased 20% within 6 hour exposure to water stress in the expense of protein degradation, and more than 25% after exposure for 48 hour, when the water potential of the leaf had dropped to -1.8 bars (Barlow et al., 1976).

Older age classes contained higher amount of nitrogen and protein than younger age classes in both clones. YK plants had lower nitrogen content in the droughted plants. The decrease in nitrogen and protein content might be aroused due to the decreased function of nitrogenase activity. For example, in Phaseolus vulgaris, specific nitrogenase activity was always lower under water stress (Ramos et al., 2003). Guerin et al. (1990) also forwarded that moisture greatly affects nitrogenase activity in legumes and in situations of extreme stress; nitrogenase activity ceases; hence, the nitrogenase activity might be affected in similar manner in enset.

The decreasing trend of nitrogen content in the leaves of droughted enset plants might be due to less availability of nitrogen in the drying soil. This is because nutrients are less mobile in a drying soil as air replaces the pores between soil particles and the root surface is less direct (Nye and Tinker, 1977). Similarly, Frew (1999) investigated that the amount of nitrogen content in the shoot depend on the availability of nitrogen in the soil, i.e. as soil nitrogen supply increased the shoot nitrogen also increased. Since the rate of ion diffusion to the root is very frequent the step limiting nutrient uptake, a decrease in soil water availability can affect plant growth (Pugnaire et al., 1994). Chapin (1991), and Heckathorn and Delucia (1995), similarly, found a decreasing trend in foliar nitrogen concentration during drought in prairie grasses which were supposed to be attributable to three processes: drought induced translocation of shoot nitrogen to roots and rhizomes, volatilization of foliar nitrogen and drought related dilution of shoot nitrogen resulting from a greater impact of drought on soil nitrogen uptake than growth. Thus, when water stress was imposed on the soil, nutrient absorbed was poorly translocated to the leaves; the consequence was a significant reduction in leaf nitrogen content after water stress.

The protein and nitrogen content decreased in the case of droughted plants. This might be because of the degradation of protein to amino acids as a protective mechanism by increasing the solute pool of the cells. Tilahun Amede and Schubert (2003) reported that when crops are exposed to drought, there is commonly an increase in the solute-pool of the plant tissue and the composition of the solute-pool varies from species to species. They found that the major osmotica in chickpea were sugars and sugar alcohols contributing to more than 50% and amino compounds contributing to 20% of the osmotic pool.

Summa ACs of YK contained higher nitrogen content than the rest age classes in the irrigated condition but it became reversed in the droughted condition. This implies that the effect of the drought with respect to nitrogen content is more severe at younger ACs than older ACs in YK plants; however, NH plants contained high nitrogen content at assat stage in the irrigated condition and the reverse became true in the droughted condition. As it was described in the growth parameters, NH plants showed some sort of sensitivity to drought compared with that of YK. A decrease in nitrogen causes 38 to 51% of the loss of photosynthesis capacity during drought and accounted for 51 to 69% of the total loss of photosynthesis capacity integrated over the post drought recovery period (Heckathorn et al., 1997) because the majority of leaf nitrogen (75% or more) is associated with photosynthesis and photosynthesis rates are strongly correlated with nitrogen content (Field and Mooney, 1986).

Conclusion and Recommendation

Total nitrogen and crude protein contents of the experimental plants did not show consistent variation between age classes and clones. The absence of significant variation in response to drought stress can be taken as an important clue for the claim that enset is a seasonal draught tolerant plant.

In order to use enset as a famine buffer plant in drought prone areas of Ethiopia, further investigation of the variation between age classes and different clones of enset in response to different environmental conditions is highly recommended. Considering the food value of enset, this can have important implications to combating food deficit in drought prone areas. Thus, a more integrated research by the responsible organizations and individual researchers is recommended on utilizing the untapped potential of the multipurpose enset plant.

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REFERENCES


