

## Laboratory Study of Standardized Shear Energy of Alfalfa Stem to Estimate Some Nutritional Quality Indices

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### Introduction

Current study tries to find a new simple and practical real-time technique to estimate forage crop nutritional quality indices at field conditions. Estimating these indices help producers to have field quality variation layer to reach the goals of Precision Agriculture. Previous studies have shown that standardized shear characteristics of crop stem would be a good indicator for some nutritional quality indices. In previous studies, laboratory tests were conducted at controlled conditions of crop moisture content, stem diameter and employing standard shear test procedure.

### Materials and Methods

In order to simulate field conditions, a two-stage study was conducted in Iran and United States. In the first stage fresh and naturally sun dried alfalfa stems were used in evaluating four levels of crop growth stage and eight loading conditions (four loading rates and two stem conditions). In order to evaluate the effectiveness of shear technique with respect to the conventional harvest method in Iran, shear tests were conducted using fixed and moving knives of a standard square hay baler (John Deere-348). Special fixtures were constructed to attach these knives to a universal testing machine (SANTAM, STM-20). Since evaluation of the suggested method with regard to other quality related factor indices such as different varieties and seeding rates, was not practically feasible in Iran in the second stage of this research, five different varieties and three seeding rates were tested in United States. In this part of the study, shear tests were conducted using modified Varner-Bratzler shear test with universal testing machine (TESTRESOURCES-311). Based on the results of loading rate and stem condition in the first stage, shear tests were carried out using loading rate of 500 mm/min and multiple stem condition. In both stages Specific Shear Energy (shear energy per stem diameter,  $J\ mm^{-1}$ ) were calculated using trapezoidal method. In order to compare the shear energy results with crude fiber nutritional quality indices such as Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF) and Relative Feed Value (RFV), all alfalfa samples were analyzed using (Association of Official Agricultural Chemists) AOAC standard analytical laboratory methods. Statistical analyses were consisted of ANOVA mean comparison test at each level of factors and regression analysis to find the correlation between specific shear energy and nutritional quality indices.

### Results and Discussions

Results of ANOVA analysis and mean comparisons showed a significant difference in specific shear energy at different levels of loading rates. The higher loading rates showed lower energy which was related to lower ability of knives to cut alfalfa stem thoroughly and shredding the stems at lower speed levels. Significant differences were found in different levels of annual growing cycle, harvest time and seeding rates. Alfalfa stem in fifth harvest year showed the highest shear energy due to higher lignification in plant stems. In the first year, harvested alfalfa stem did not have the lowest shear energy which might be due to existence of weeds in first year field. Results showed higher values of shear energy in fifth harvest of the season in comparison with the third harvest which was acceptable because of differences in plant received Degree Day in these harvest times. The lowest seeding rate ( $5\ kg\ h^{-1}$ ) showed the highest shear energy respect to the other seeding rates. The reason for this significant difference could be due to lower competition to receive water and nutrients, also lower plant

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density helps the canopy to receive more sun light which causes higher lignification. Comparing the shear energy means in different varieties didn't show significant differences which can be explained because of varieties adoptability to the region specific weather condition. The regression analysis showed good correlations between specific shear energy and crude fiber nutritional indices (ADF, NDF and RFV). The negative trends which were found in regression analyses were also reported in similar studies.

### Conclusions

Two stage laboratory tests were conducted in order to evaluate the effect of alfalfa nutritional feed quality indices related factors on unitized shear energy. Results showed a significant difference of standardized shear energy mean at different levels of harvest time, annual growing cycle and seeding rates. The specific shear energy was not significantly different in different varieties because of varieties environmental adoptability. The unitized shear energy showed a good correlation with crude fiber related indices with similar trends in both stages of research and good agreements with previous studies.

**Keywords:** Forage, Nutritional quality indices, Precision agriculture, Unitized shearing characteristics