Research Journal of Animal Sciences 10 (1-6): 1-5, 2016
ISSN: 1993-5269

Effects of Agro-Ecologies on Forage Species Quality

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Abstract: This review study was prepared with the objective of to revise the available scientific information about agro-ecological factors which are affecting the nutritional and biomass yield of forage species. There are several factors which are hindering livestock production on the world. Among them feed relating problem are the main constraints of livestock production. Therefore, to avail the feed relating problem knowing of the major factors which are affecting the animal feed quality and quantity have paramount importance. Among several factors which are influencing nutritive value and yield, agro-ecologies in which the forage species produced have vital role. Growing conditions (such as soil type, fertility, local climate, moisture conditions and pest pressure), stage of maturity at harvest, weather conditions during cutting, moisture at raking and baling and storage conditions are some of the factors which are influencing the growing condition and nutritive value of plant species. The nutritive value of a forage is the consequence of the conditions of plant growth. Understanding how environmental conditions and management factors interact to influence forage quality is important in making production decisions. The most obvious direct effect is leaching of nutrients from plants by rain. Many environmental conditions affect the chemical composition of plants indirectly, often by causing changes in the form or in the phenological development of plants.

Key words: Forage specie, nutritive value, agro-ecologies, phenological, chemical composition

INTRODUCTION

The evolution of livestock rising requires intensive production systems in which the use of high quality forages is fundamental. Forage quality is a direct reflection of essential nutrient content and availability to the consuming animal or it is defined as the sum total of the plant constituents that influence an animal's use of the feed. Three processes define forage quality: an animal's ability to consume (intake), digest (digestibility) and assimilate (availability) essential nutrients contained within the feed. The most important factors which influence plant growth and forage quality include growing conditions (such as soil type, fertility, local climate, moisture conditions and pest pressure), stage of maturity at harvest, weather conditions during cutting, moisture at raking and baling and storage conditions. The composition and quality of hay or silage is the cumulative result of its history. Management of forage for maximum yield and quality requires an understanding of how environmental/agro-ecologies and management factors influence crop growth and development. Environmental conditions such as weather, soil, plant competition and grazing can directly or indirectly affect the nutritive value of plants for grazing animals. The most obvious direct effect is leaching of nutrients from plants by rain. Many environmental conditions affect the chemical composition of plants indirectly, often by causing changes in the form or in the phenological development of plants. The study of these effects is complex because single factors rarely act alone; most changes in the nutritive status of a plant are caused by numerous, interrelated factors whose effects often cannot be separated. Even when the effect of a single factor can be isolated, the mechanism of the change in composition of a plant may be very complex. These interactions must be remembered in any evaluation of plant nutrient content and forage value.

MATERIALS AND METHODS

Effects of agro-ecologies on forage species quality

Precipitation: The amount and distribution of precipitation affect chemical composition of plants both directly and indirectly. The direct effect is leaching of nutrients from herbage. The indirect effect is caused by variations in the amount of soil moisture available for plant growth. Leaching of mature or dry herbaceous plants as a result of exposure to rain often results in large decreases in protein, phosphorus ash and carotene. Crude fiber and lignin are not leached and thus increase in percentage as leaching progresses (Guilbert and Mead, 1931; Watkins, 1937, 1940). Not all species react in the same way to leaching. Watkins (1937, 1940) found that calcium content in various range grasses was significantly reduced by heavy Winter precipitation while Savage and Heller (1947) found that calcium content of grasses is little influenced by leaching. For animal nutrition, leaching of nutrients from dry or mature herbage is probably most significant; however, leaching of considerable amounts of nutrients from actively growing plants by rain, mist or dew also occurs. Many constituents important to plant growth and animal nutrition are affected by leaching: calcium, iron, manganese, nitrogen, phosphorus, potassium and various carbohydrates. Because of this leaching in the field, chemical composition of plants grown in the greenhouse cannot be considered representative of the chemical composition of the same plants grown in the field. The amount leached from leaves depends on several environmental influences and upon the condition of the plant. Young leaves are less susceptible to leaching than are older leaves. Injury to leaves by frost, disease, insects or mechanical means increases leaching loss. When these membranes are injured, their differentially permeable characteristics are destroyed; thus, there is greater movement of metabolites out of the cells when they are in contact with leaching solutions (Tukey and Morgan, 1963). Therefore, leaching might be more pronounced from grazed plants than from ungrazed plants. Frosts folowed by rain also might increase leaching losses and thus reduce the nutritive value of range plants. Intensity and volume of rain affect degree of leaching. A light drizzle over a long period removes considerably more nutrients than an intense storm does. Dew is an effective leaching agent, especially in seasons and climates where rainfall is low. Other factors that influence leaching are light, temperature and the nutritional status of the plant.

Temperature: Temperature is important in determining rate of development, phenology and total yield of many plants, thus indirectly influencing chemical composition. However, effects of temperature are often confounded with effects of rainfall and other influences. It is clear that high temperatures are generally detrimental to plant growth but distinguishing response to temperature from response to a moisture deficiency caused by the high temperature is difficult. In herbaceous plants in active growth or in the flowering stage, an increase in air or soil temperature up to 80°F often increases the nitrogen (protein) content in the foliage. In growth chamber studies, Brown (1939), Bowman and Law (1964) determined that the percentage of protein of grasses increased as temperatures increased from 60° or 65-80°F. Similar increases in percentages of nitrogen in the foliage of various plants, caused by increases in soil temperatures up to 80°F were reported by Nielsen and Cunningham (1964). These increases may have been at least partly related to morphological changes in plants. In some studies grasses were reported to have a higher leaf-to-stem ratio at higher temperatures. Leaves of grasses usually contain more protein than stems (Cook, 1959); thus, more leafy plants would be expected to have higher protein content.

Increases in percentage of phosphorus in foliage with increased soil temperature were reported by Nielsen and Cunningham (1964), Levesque and Ketcheson (1963). However, increased temperature does not cause increases in nitrogen and phosphorus in all species (Nielsen and Cunningham, 1964). The response of other nutrients to temperature is quite variable. A decline in content of nitrogen-free extract with increasing temperature was reported by Brown (1939) and declines in lignin and cellulose content with increasing temperatures were reported by Bowman and Law (1964). Brown (1939) found ash content little affected by temperature. Mellin *et al.* (1962) found that protein content and digestibility which normally decreased approached maturity, increased somewhat after a week of low temperatures and above-normal rainfall. However, this change was probably due to increased soil moisture and to a delay in maturity rather than to temperature.

Light intensity: Lack of adequate light has definite effects on plants; some effects are direct but most are indirect. Stage of development is often retarded in shaded areas (McEwen and Dietz, 1965) and soil moisture is higher in shaded areas (Cook, 1959); therefore, shaded plants remain succulent longer during the summer. Since, protein and moisture content have a high positive correlation, higher moisture content of plants is probably responsible for the presence of more protein in shaded plants. Reduced leaching because of intercept of rain by over story species might also be a factor. Even the effect of shade on total production is not clear in all studies. Welton and Morris found that artificial shading had the same effect as tree cover in reducing carbohydrate content of grasses but artificial shading did not reduce total yield because there was no competition for soil moisture from the tree species. However, in other studies under controlled conditions, reduced light levels have decreased production of some species. However, shade-tolerant species may be affected very little by low light intensities

Soil: A great many studies have shown that plants of the same species grown in different soils often differ in chemical composition and consequently in palatability (Heady, 1964). Even when the causes of differences in soil were defined, other influences may have been acting in conjunction with those defined or were confounded with them. Beeson (1941) stated this very clearly: "while plants are dependent upon the soil for their mineral nutrients, climatic conditions so affect physiological processes that the composition of both the mineral and the organic matter of crops may be greatly modified even though the crops are grown upon identical soils. Plant composition is modified by both the climate and the soil in which it is growing and both these factors are closely interrelated, often modifying the effect of the other. Thus, the assimilation of phosphorus growing in calcareous soils may be less in dry than in wet years whereas entirely contrary results may be obtained in plants growing in siliceous soil. Crops growing in the same soil type separated by sufficient distance so as to not receive the same amount of rain fall at the same time in any 1 year may be quite different in their chemical composition." Various soil factors that affect chemical composition are discussed.

Soil moisture: The amount of soil moisture available for plant growth affects both the yield and chemical composition of plants. However, in most studies of plant composition, effects of soil moisture are confounded with temperature, stage of plant maturity and many other factors. Early in the growing season soil moisture is often abundant and most herbaceous plants are green and growing rapidly; the moisture, protein, phosphorus and carotene content of such plants generally is high whereas the fiber, lignin and nitrogen-free extract content is low. During the middle and latter part of the growing season in temperate regions with a continental climate, precipitation and soil moisture decrease, temperature increases and herbaceous plants grow to maturity and become dry. As these events occur, the following changes take place in most herbaceous plants:

- Percentages of protein and phosphorus decrease Percentage of carotene decreases
- Percentages of nitrogen-free extract and crude fiber or lignin increase
- Digestibility of most plant constituents decreases
- Percentage of tannin increases in plants that contain this compound

Most of these changes result from plant maturity and are only indirectly affected by the decrease in soil moisture. However, early drying of soil under drought conditions makes plants dry or mature earlier which in turn, hastens the seasonal changes in chemical composition. The decrease in protein as soil moisture becomes deficient is at least partly caused by a breakdown of protein occurring as leaves wilt. Late summer or fall rains replenish soil moisture and cause green regrowth of plants which is more nutritious to animals than the dry herbage. Soil moisture and stage of growth affect ether extract ash and calcium content in various ways, depending on species and location. In some species percentages of ether extract and ash decrease as soil moisture decreases and as plants mature. However, the trend is less regular than for protein or phosphorus and no change occurs in some species. Calcium content of grasses has been reported to decrease during drought. However, Orr *et al.* (1929) found that irrigation caused little change in calcium content. Increases in calcium with increase in maturity of grasses were reported by Orr *et al.* (1929). Savage and Heller (1947) found no correlation between stage of growth, time of year or precipitation and calcium content of grasses but found that calcium increased in forbs as plants matured. Chemical composition of leaves of deciduous shrubs often follows the trends just described for grasses and forbs during the growing season. However, chemical composition of some shrubs may not be strongly affected by summer drought or season because shrubs often have deeper root systems and thus are assured of more soil volume from which to draw moisture.

RESULTS AND DISCUSSION

Soil depth: Cook (1959) studied the chemical composition of seeded grasses on deep, sandy loam soils and shallow, rocky, clay loam soils in Utah. Plants on the shallow soil contained more protein and ash and less lignin and cellulose and were more palatable to livestock than the plants on the deeper soil. However, soil depth was only indirectly responsible for this difference; plants on the shallow soil were more leafy and had smaller stems than those on the deep soils. The leafy characteristic probably explains the higher palatability and generally better nutritive quality of the plants on the shallow soils. Digestibility of the plants was not studied but it would probably be higher on the shallow soil because of the lower lignin content. Stoddart (1941) compared the chemical composition of Symphoriccvrpos rotundifolins on three soils of different depths. Plants on the deeper soils had more ash and phosphorus than those on shallower soils but about the same amounts of other nutrients.

Nutrient content of the soil: Many studies show that the nutrient status of plants is directly affected by the nutrient content of the soils. This is most clearly shown in studies of the effect of fertilizer on chemical composition. Midgley (1937) concluded that an abundance of available plant nutrients in soil is reflected in the chemical composition of the plants. Higher leaf to stem ratios may occur in plants when growth is restricted by a phosphorus or potassium deficiency. The increase in leaf to stem ratio results in greater crude protein concentrations. Adequate soil fertility, particularly phosphorus is essential in providing good early growth and weed competition. Daniel (1934) found only a slight relation between the amount of calcium and phosphorus in the soil and they concluded that plants normally low in calcium and phosphorus remain low even when grown in fertile soils and that plants normally high in these elements remain high even when grown in poor soils.

Texture of soil: Texture of soil can influence chemical composition of plants-mainly through its effect on water holding characteristics and nutrient status. Finer soils have a higher nutrient exchange capacity and can hold more water (Midgely, 1937). However, little agreement has been found during studies comparing chemical composition of plants on soils of different textures. Archibald and Bennett (1933) reported that loams and sandy loams with a compact substratum had good water-holding capacities and produced herbage higher in protein and calcium and lower in crude fiber than excessively drained sandy loam soils. Plants grown in sand were lower in phosphorus content than those grown in loam but that the content of other constituents was not affected by texture. Compaction of soil can also affect the nutrient status of plants but little research on this has been reported. The nitrogen content of corn grown in compacted soil was significantly less than that of plants grown in less compacted soil. Content of phosphorus and potassium in plants was not affected by soil compaction.

Altitude: Altitude affects plant composition through the interrelation of light intensity, carbon dioxide concentration, temperature, precipitation and length of growing season (Oelberg, 1956). Development of plants is often delayed and precipitation is often greater at higher elevation (McEwen and Dietz, 1965). Therefore, plants at different elevations compared at a given time reflect composition differences due to variations in development and in soil moisture as well as the other factors mentioned above. Crude protein, phosphorus and nitrogen-free extract increased with altitude whereas crude fiber decreased.

CONCLUSION

The nutritive value of a forage is the consequence of the conditions of plant growth. Understanding how environmental conditions and management factors interact to influence forage quality is important in making production decisions. Environmental conditions such as weather, soil, plant competition and grazing can directly or indirectly affect the nutritive value of plants for grazing animals. The most obvious direct effect is leaching of nutrients from plants by rain. Many environmental conditions affect the chemical composition of plants indirectly, often by causing changes in the form or in the phenological development of plants.

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