EFFECT OF HARVEST TIMING ON YIELD AND QUALITY OF SMALL GRAIN FORAGE

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ABSTRACT

Small grain forage represents a significant crop alternative for silage or hay production, but information on forage and yield changes with maturity is often lacking. Small grain forage plots were harvested multiple times throughout the growing season in Tulare County during 2002 and 2004 to track changes in yield and quality. In 2002, wheat and triticale plots were sampled to evaluate forage quality for 10 consecutive weeks from March to May. Standard laboratory forage chemistry tests were used to measure chemical components (protein, fiber, non-structural carbohydrate, lignin, ash) which define nutritive value. Fiber digestibility was estimated using 30-hour, *in vitro* incubations. Energy value of the forage was estimated from prediction equations based on fiber digestibility. In 2004, wheat and triticale plots were weighed and sampled at four growth stages; boot, flower, milk and soft dough. Yield of forage was determined and the aforementioned forage analyses were performed for each growth stage**.**

Key words: Small grain forage, cereal forage, winter forage, forage quality

INTRODUCTION

Small grains are important forages in California. They are fed to a wide range of livestock classes including cattle, horses, sheep and goats. In Tulare County, the largest milk producing region in the world, dairy cows and heifers are the primary market for small grain forage. The forage is planted in the fall after a summer crop of corn, and is harvested and ensiled in the spring. Dairy producers group cows and heifers in pens that have similar nutritional requirements depending on milk production or growth stage. Consulting nutritionists formulate rations to meet the needs of each group. Accurate descriptions of forage quality are essential to enable formulation of rations that maximize milk production or growth. Cereal forage quality descriptions have often been difficult to obtain.

Quality testing programs for alfalfa have been in place for decades based on research that has shown greater digestibility, faster weight gains, and higher milk production from cattle fed alfalfa harvested at an immature stage. Maturity of alfalfa is closely related to its fiber content. As stage of maturity increases, so does its fiber content. For alfalfa, there is a negative correlation of digestibility with fiber. Laboratories that test alfalfa hay predict total digestible nutrients (TDN) and Net energy for lactation (NE_l) from its fiber content. These values in turn are used to establish relative economic value of different lots of hay. Small grain forages have

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certain features that are very different from alfalfa. The percentage of fiber does not always increase with increasing maturity. During early growth up to flowering, fiber content (ADF and NDF) increases as the plant matures, similar to alfalfa. However, when grain is produced, the relationship becomes more complex. The fiber level is usually lower or about the same at soft dough as it is at boot stage, due to the development of the grain. As the plant matures, grain development contributes non-fibrous (or non-structural) carbohydrate (starch) that dilutes the fiber component. The negative effects of more fiberous stems and leaves are often more than compensated by development of the non-fiberous, high energy grain portion.

Energy prediction equations used for alfalfa can not be used to accurately describe TDN or NE_l for small grain forages. This situation makes it difficult to accurately formulate rations containing small grain forage. Methods that predict the energy value of small grain forages more reliably have been developed. These methods employ *in vitro* digestion, a procedure in which samples of the forage are incubated with rumen fluid from a cow. We conducted trials in 2002 and 2004 to evaluate changes in forage quality using standard and *in vitro* methods.

PROCEDURES

2002 Season: Weekly forage samples were collected from three wheat cultivars (Yecora Rojo, Bonus, Brooks) and one triticale cultivar (Trical 96) which had been planted in ¾ acre replicated plots in a farm field southeast of Tulare, California. Plant height and Zadok's scale readings (a measure of plant development) were taken at each sampling for ten weeks from March 1st to May 8th. Dry matter content was determined each week. After the last sampling, samples were submitted to a commercial laboratory (JL Analytical Services, Inc., Modesto, CA) for analyses of chemical components (crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) non-fibrous carbohydrate (NFC), and ash). Neutral detergent fiber digestibility (NDFD) was estimated using 30-hour, *in vitro* incubations. Prediction equations for energy value (TDN and NEl) were developed based upon NDF and CP ('Recommended UC Forage Energy Predictions'):

$$TDN = 80.54 - (0.52858 * NDF) + (0.43147 * CP)$$
$$NE_l = 0.820 - (0.00661 * NDF) + (0.00557 * CP)$$

2004 Season: Forage samples were collected from three common wheat cultivars (Plata, Summit, Stellar), one durum wheat (Crown) and one triticale cultivar (Trical 96**)** which had been planted in ½ acre, replicated plots in a farm field north of Tulare. Swaths measuring 4' x 10' of each forage were cut, weighed and sampled at four growth stages; boot, flower, milk and soft dough. Dry matter content was determined for each harvest. After the last sampling, samples were submitted to the UC Davis DANR laboratory for analyses of chemical components (CP, ADF, NFC, lignin and ash). NDF and NDF digestibility (NDFD) determinations were made by a commercial laboratory (Cumberland Valley Analytical Laboratory, Hagerstown, MD). Prediction equations developed from the 2002 data were used to estimate energy content (TDN and NE_l) of the forages.

RESULTS

In the charts that follow, all values of CP, ADF, NDF, ash, lignin and TDN are expressed as a % of DM. NE_l is expressed in Mcal/lb of DM. NDFD is expressed as a % of NDF. TDN is estimated at 1xM (low feed intake), and NE_l is estimated at 3xM (high feed intake).

2002 Season: Protein was highest at boot stage and declined for all cultivars as they matured (Figure 1). NDF digestibility declined from early March (80 days after planting) to mid April (122 days after planting) for all cultivars, and then rebounded (Figure 2). From mid April to early May, ADF and NDF declined to near boot stage levels (Figures 2, 3, and 4). NDF increased slowly from early to late March (73 to 100 days after planting) and then increased more rapidly to a peak in mid April (115 days after planting – Figure 3).. TDN was highest in March and dropped steadily through early April from 73 to 109 days after planting for all cultivars (Figure 5). In mid April, TDN leveled off and rebounded slightly until the last sampling in early May. There was a rebound in NDFD for two wheat cultivars (Yecora Rojo and Bonus) from mid to late April (Figure 6). The NDFD for the other wheat cultivar (Brooks) and Trical 96 triticale did not increase. The NDF digestibililty is expressed as the percentage of NDF that is digestible in rumen fluid at a given length of time (in this case, 30 hrs).

2004 Season: The percent DM and yield of DM per acre increased for all cultivars as they matured from boot to soft dough stage (Figure 7). Percent DM was on average only 18% at boot and 36% at soft dough stage. Yield averaged 1.7 tons dry matter at boot and increased to 7.6 tons/acre dry matter at soft dough stage (Figure 7). When adjusted to 30% DM, the yields were about 6 tons at boot and 22 tons/acre at soft dough stage. NDF increased to flowering, but then declined dramatically (Figure 8) Digestible NDF was highest at boot stage and decreased for all cultivars as they matured (Figure 9). ADF followed a similar trend as for NDF (Figure 10). CP and ash were highest at boot stage and decreased for all cultivars as they matured (Figure 11). CP averaged 19% at boot and dropped to 12% at soft dough stage. ADF and NDF were highest at flower stage for all cultivars. Lignin was also highest at flower stage for all cultivars except Stellar, for which lignin was highest at milk stage (data not shown). TDN and NE_l were lowest at flower stage (Table 12). Trends for parameters measured were similar for all cultivars.

Here is a summary of the work completed to date:

- Small grains can provide high quality forage for dairy cattle, but quality depends on the stage of maturation at the time of harvest, and it declines with plant maturity.
- Highest DM yield occurred at soft dough stage. Since DM yield is often the primary objective of many growers and dairy producers, most small grain forage grown in the Tulare area is often harvested at this stage.
- In both years, CP declined with advancing maturity for all seven cultivars of wheat and the triticale cultivar.
- There were small differences between grain types in quality parameters.

DISCUSSION

Time of harvest of small grain forages has a large effect on the yield potential. Yields in some cases quadrupled from boot to soft dough stage (Figure 7). Highest DM yield occurred at soft dough stage. Since DM yield is often the primary objective of growers and dairy producers, most small grain forage grown in the Tulare area is harvested at this stage. Although CP and NDFD are lowest, TDN and NE_l are highest at soft dough. Higher concentration of energy coupled with higher DM yield makes soft dough stage the obvious choice for obtaining the highest yield of energy per acre. There are situations when growers wish to remove a small grain forage crop before it matures to soft dough stage to enable earlier planting of corn. If harvest must occur early, then the best time would be boot stage, when CP and NDFD are highest.

In 2002, sample collection began March 1st when the forage had just finished tillering - a very immature stage. In 2004, sample collection began at boot stage, later than in 2002. So when comparing trends for change with advancing maturity in a chemical component, the 2002 data starts earlier than the 2004 data. Zadok's scale assessments of maturation for the small grains in our trials indicated that the triticale and especially the durum wheat were physiologically less mature than the other wheat cultivars. Even slight differences in maturity could account for differences in chemical components among cultivars at each harvest stage. CP declined dramatically with advancing maturity for all the small grains in both years. Fiber concentration (whether ADF or NDF) increased until approximately flowering time, but then declines (in some cases dramatically) after significant seed development. TDN often improves from the milk to the soft dough stages of harvest.

SUMMARY

Small grain forages are extremely versatile, economical sources of feed that have long been over shadowed by alfalfa and corn silage. Standard laboratory tests and prediction equations for defining nutritional value have not been commonly used for small grain forages. Inaccurate feeding value information may be part of the reason why these forages have not been utilized to their full potential. The introduction of *in vitro* procedures for estimating energy value will provide more reliable information that can help nutritionists and producers take full advantage of the nutritional attributes of small grain forages

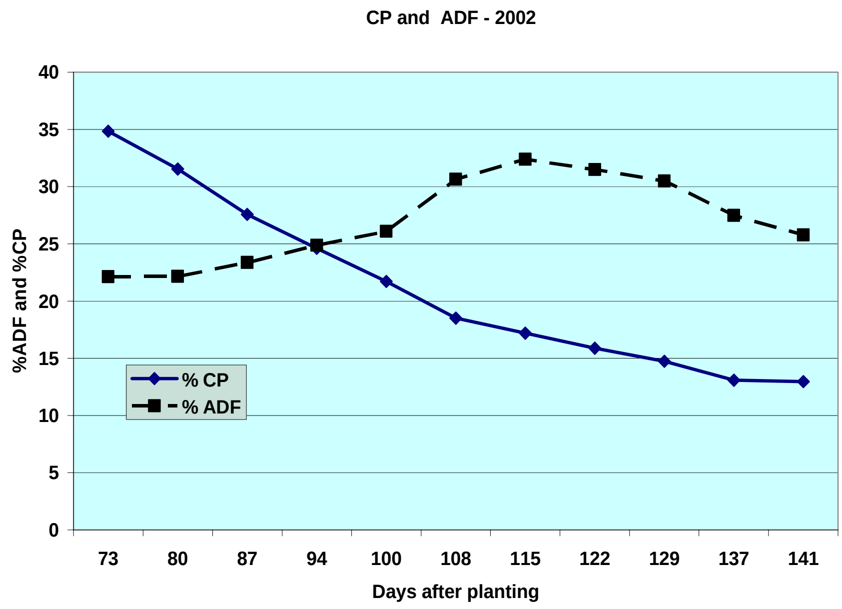

Figure 1. Growth Stage Effects on Small Grain CP and ADF, Tulare Co., California, 2002

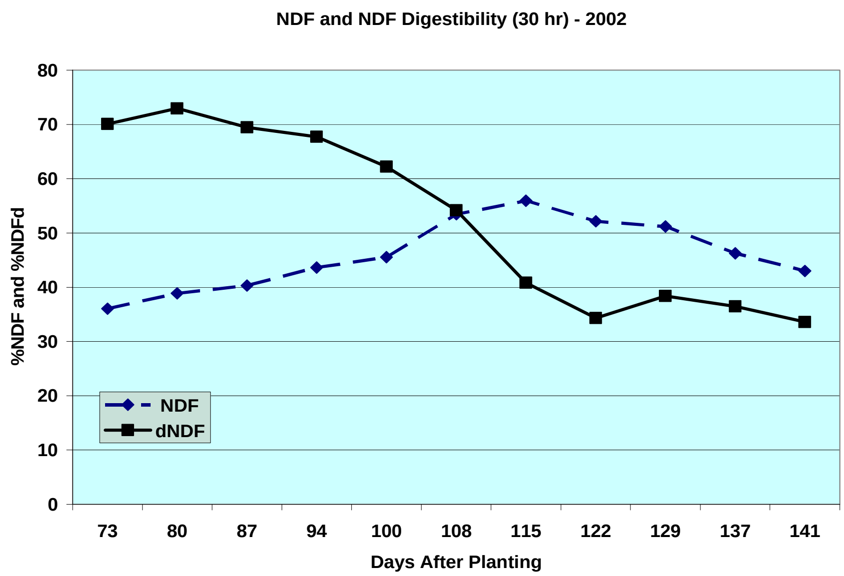

Figure 2. Growth Stage Effects on Small Grain NDF and NDF Digestibility (30 hr), expressed as a percentage of NDF, Tulare Co., California, 2002

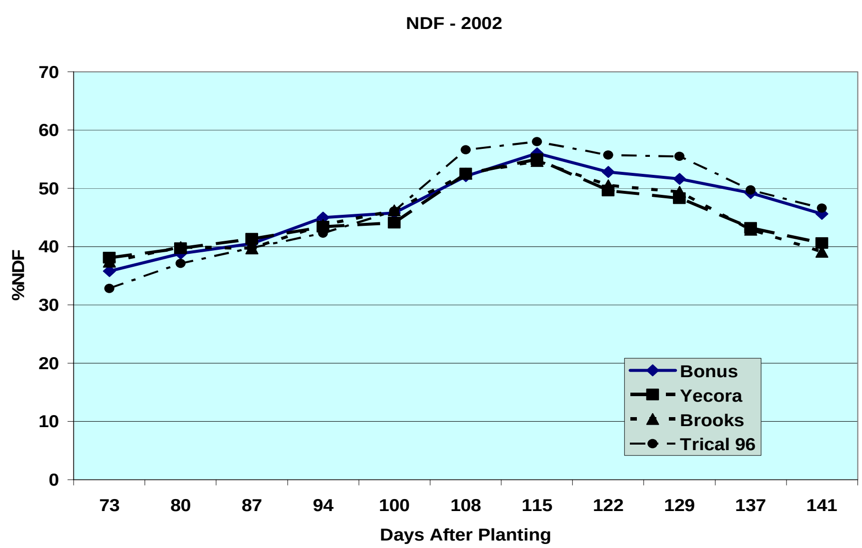

Figure 3. Growth Stage Effects on Small Grain NDF of 4 varieties, , Tulare Co., California, 2002

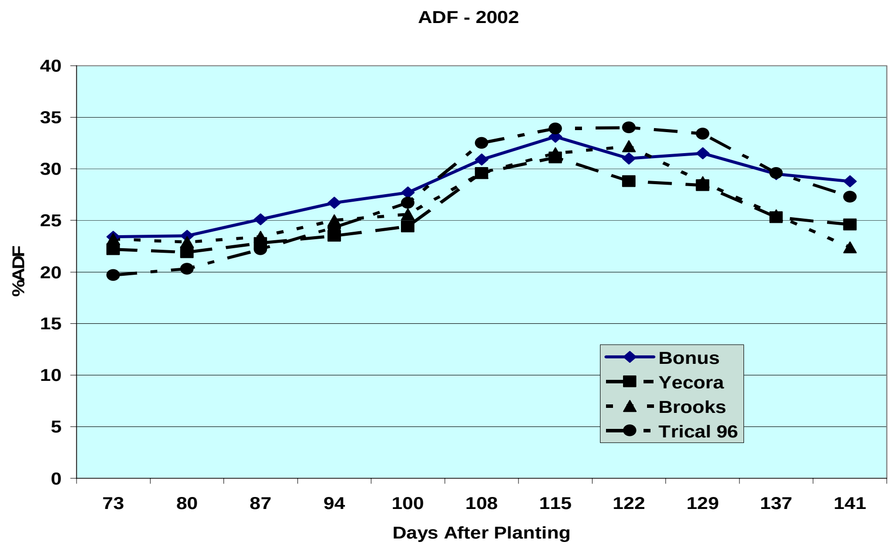

Figure 4. Growth Stage Effects on ADF concentration of of 4 small grain varieties, Tulare Co., California, 2002

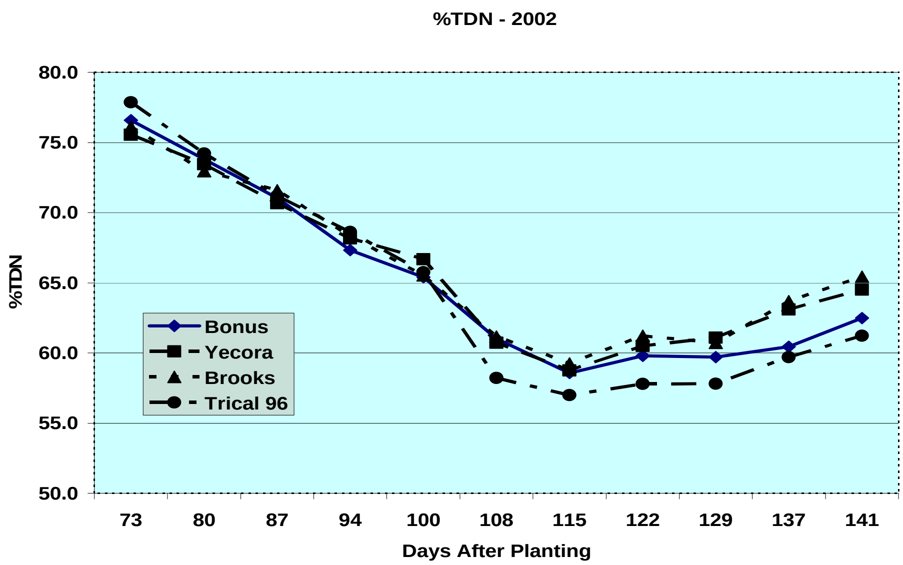

Figure 5. Growth Stage Effects on %TDN concentration of of 4 small grain varieties, Tulare Co., California, 2002

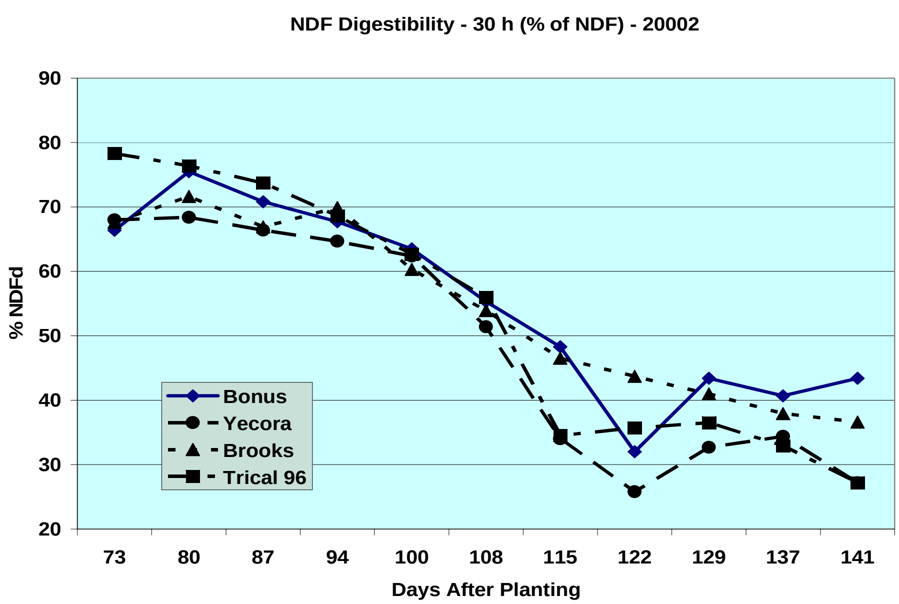

Figure 6. Growth Stage Effects on NDF Digestibility (30 hr) of of 4 small grain varieties, Tulare Co., California, 2002

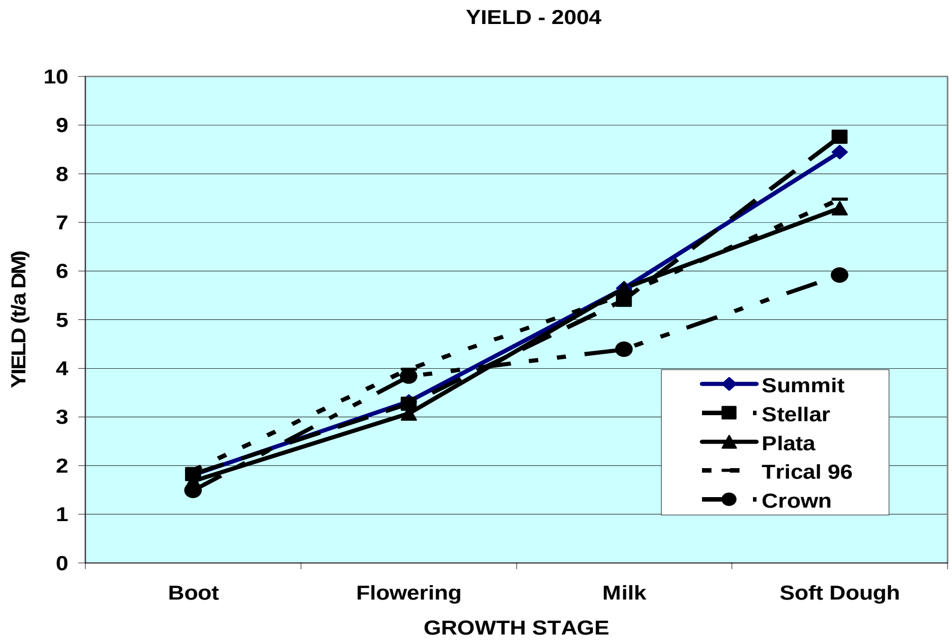

Figure 7. Growth Stage Effects on Small Grain Yield, Tulare Co., California, 2004

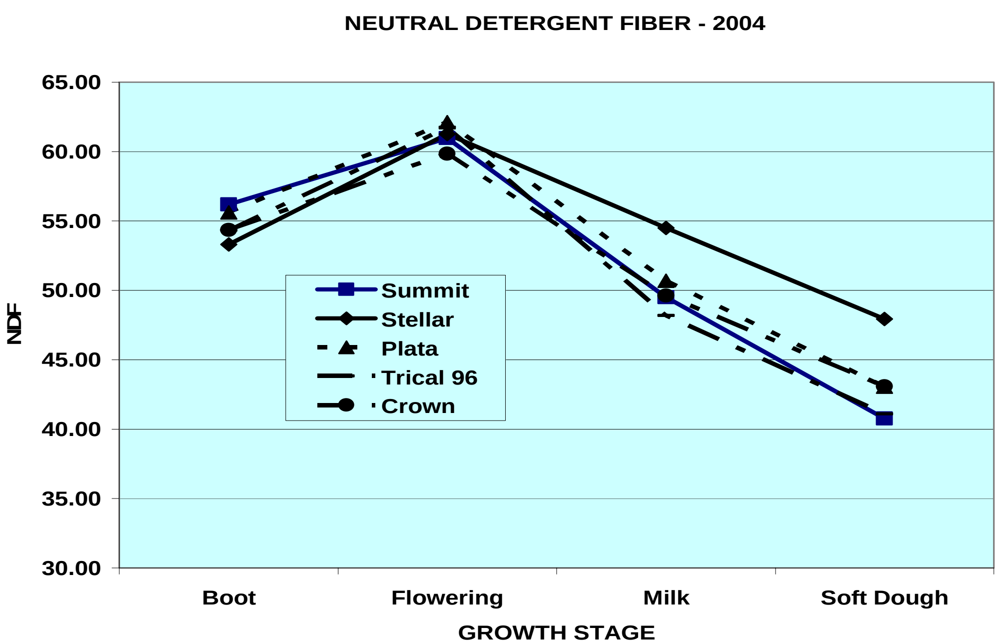

Figure 8. Growth Stage Effects on Small Grain NDF Concentration,, Tulare Co., California, 2004

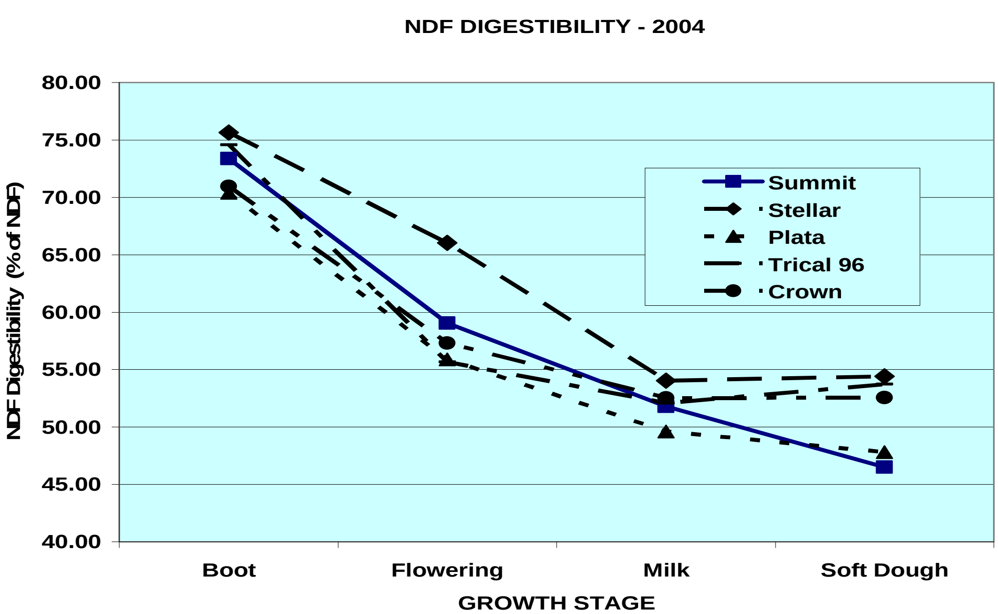

Figure 9. Growth Stage Effects on NDF Digestibility (as % of DNF, Concentration) of small grain forages, Tulare Co., California, 2004

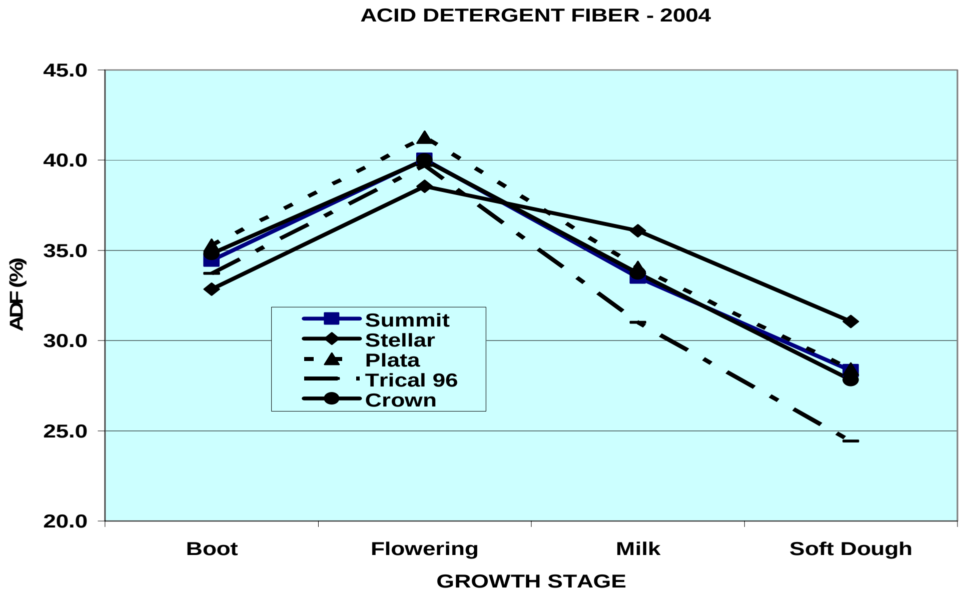

Figure 10. Growth Stage Effects on ADF Concentration of small grain forages,, Tulare Co., California, 2004

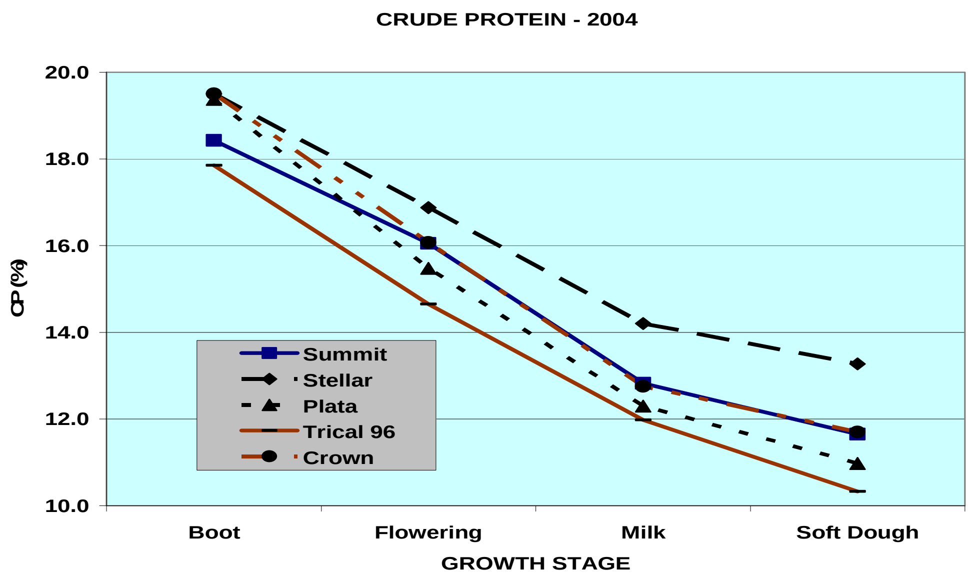

Figure 11. Growth Stage Effects on Crude Protein Concentration of small grain forages,, Tulare Co., California, 2004

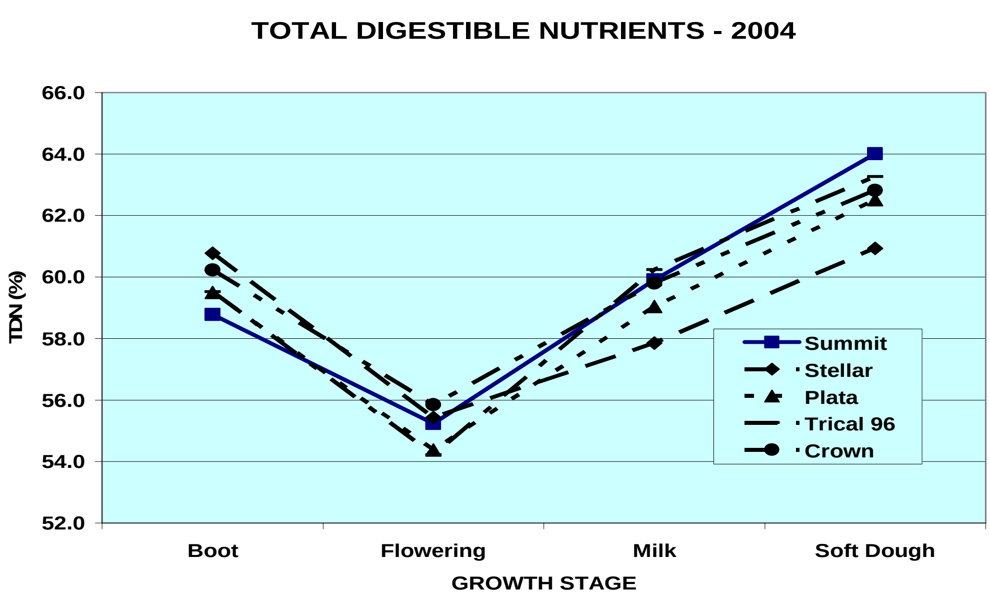

Figure 12. Growth Stage Effects on TDN Concentration of small grain forages, Tulare Co., California, 2004