# LIQUID VS. DRY SUPPLEMENTS FOR GRAZING BEEF CATTLE

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## Introduction

When cattle consume forages as the only energy source, intake of net energy (NE) may not be adequate to meet desired rates of animal performance (i.e., daily gain or milk production). In such cases, energy supplements must be provided in order to attain the desired performance. When concentrate feeds are fed as supplements, animal responses may not be as expected in some cases. The deviation between expected and observed performance may be due to effects of concentrates upon voluntary forage intake (increase or decrease). Also, there may be associative effects between concentrates and forages which result in metabolizable energy (ME) concentrations of mixed diets that are higher or lower than expected values. Because of the widespread use of liquid supplements for grazing beef cattle in Florida, it is of interest to know if effects of liquid and dry supplements on forage utilization and animal performance are similar.

At the 1995 Florida Ruminant Nutrition Symposium, the effects of dry supplements on voluntary forage intake and ME concentration of the mixed diet were discussed (Moore and Kunkle, 1995). The purposes of this paper are to 1) describe the effects of liquid supplements on animal gains and forage intake, 2) compare the effects of dry and liquid supplements, and 3) present equations that estimate changes in animal performance of cattle fed liquid supplements.

## Effects of Liquid Supplements on Gain and Intake

A data base was developed from 21 publications reporting effects of liquid supplements on performance of cattle grazing or fed on 53 forages (Moore et al., 1995). Studies included in the data base were limited to those that included a non-supplemented control treatment and at least one treatment where a molasses-based supplement was fed. There were a total of 151 comparisons between a control treatment and a liquid supplement treatment. Daily gains were reported for 148 comparisons, and forage intakes were reported for an additional three comparisons. All studies were conducted with non-lactating cattle, and most were growing calves or yearlings. If full body weights and gains were reported, they were converted to a shrunk basis using equations derived from full and shrunk weights on forage-fed cattle (Kunkle and Moore, unpublished). To account for variations in body weight among studies, gain and intake data were expressed as percentages of shrunk body weight.

In the 151 comparisons, 107 were conducted on pasture or range, and 44 with harvested forages or roughages. Native mixed species (mostly warm season grasses) were used in 106 comparisons, improved warm-season grasses in 30 comparisons, cool-season grasses or grass-legume mixtures in nine comparisons, and rice straw in six comparisons. Molasses alone was used in 35 comparisons, molasses plus non-protein nitrogen (NPN) in 95 comparisons, molasses plus a dry meal in 11 comparisons, and molasses plus both NPN and meal in 10 comparisons. The NPN sources were mostly urea but included biuret and several ammonium salts. The dry meals included both animal and vegetable protein sources, and corn meal. Because there were so few comparisons with each type of meal, they were grouped together for analysis. All but four of the comparisons involving meal-containing supplements were in experiments on improved warm-season forages.

No data on forage intake or diet digestibility were reported for grazing trials. In some but not all experiments, data on forage availability and(or) stocking rate were presented. Although a preliminary



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examination of the available data showed no consistent effects of these variables on animal responses, it is possible that some variation in response to supplementation may be due to variation in forage availability. This source of variation cannot be accounted for in this paper, however.

All reports on harvested forages included forage intake, but digestibility was reported for only 15 comparisons. For the other 29 comparisons, digestibilities were estimated from data on intake and gain. Equations provided by NRC (1984) were used to estimate NE intakes, and these values were converted to digestible energy intake, digestible OM intake, and digestible OM concentration.

Forage CP concentration was reported for only 48 of the grazed and 38 of the harvested comparisons, and when forage CP concentration was not reported, no tabular value was used. The data base is reduced, therefore, from 151 to 86 comparisons when forage CP concentration is considered. When supplement DM, OM, CP, and DE or ME concentrations were not reported, tabular values for ingredients were used to calculate nutrient concentrations in supplements. All intake and nutrient concentration data were converted to an OM basis. When actual OM concentrations were not reported, a value of 93% OM in DM was assumed.

<u>Liveweight gain response to liquid supplements - grazed and harvested forages combined</u>

In general, the feeding of liquid supplements (Figure 1, dashed line) increased gain over that on forage alone (Figure 1, solid line), but the response was quite variable and supplement decreased gains in a few cases. The improvement in gain due to supplementation decreased as animal gain on forage alone increased (i.e., as forage quality improved). The most variable response was with native forages when gains on forage alone were negative; in many cases, gains with supplement were still negative. When gains on forage alone were positive, gains were increased the most with the improved warm-season forages. Adding a source of nitrogen to the supplement (Figure 2, solid symbols, dash/dot line) resulted generally in a greater response to supplement than when no nitrogen was added (Figure 2, open squares, dashed line), but the responses were variable. Because type of forage and type of supplement were often confounded, comparisons of meal vs NPN as sources of nitrogen may not be valid. In general, however, supplements containing meal (diamonds), or both meal and NPN (solid squares), tended to give greater increases in gain than did those containing only NPN (stars).

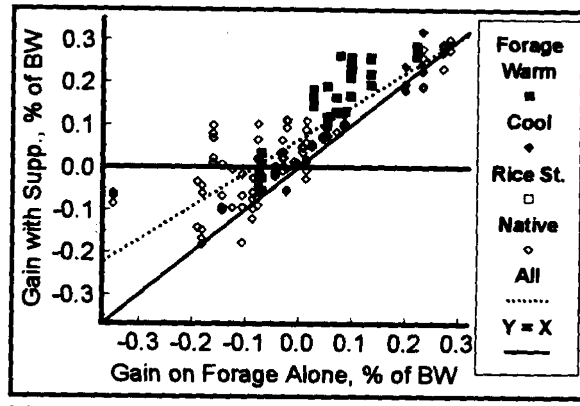


Figure 1. Daily gain on forage with liquid supplement vs gain on forage when fed alone, according to type of forage.

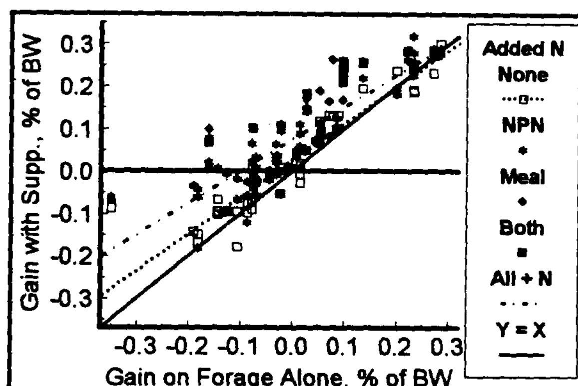


Figure 2. Daily gain on forage with liquid supplement vs gain on forage when fed alone, according to type of supplement.

There was no consistent change in rate of gain due to level of supplement intake (Figure 3), but the greatest responses were seen when supplement was fed at levels between .25 and .5% of BW (i.e., between 1.5 and 3 lb/day for a 600 lb heifer). Even at that level, however, responses in gain ranged from -.03 to +.29 % of BW. Concentration of CP in supplements with added nitrogen was not related consistently to change in gain (Figure 4),

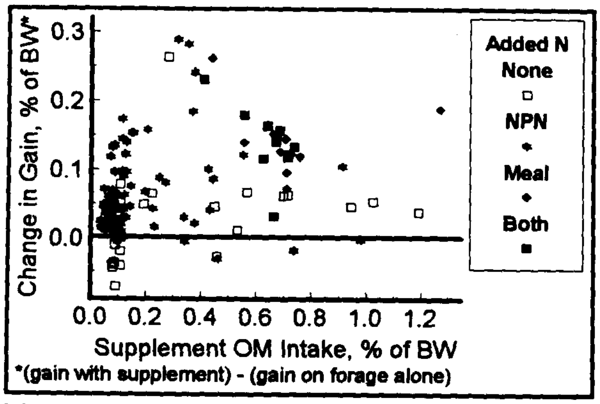


Figure 3. Change in daily gain due to feeding liquid supplement vs intake of supplement.

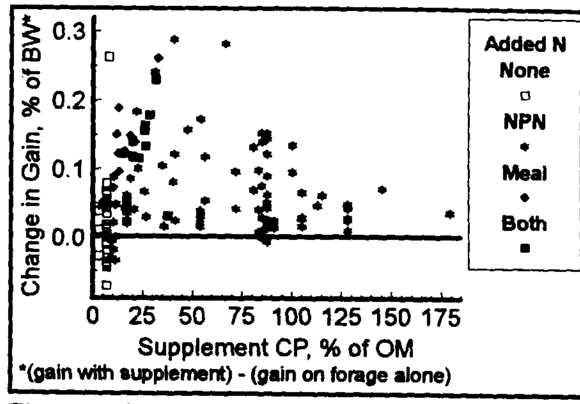


Figure 4. Change in daily gain due to feeding liquid supplement vs supplement crude protein (CP) concentration.

but gains were almost always increased when supplemental CP concentrations were above 15% of OM. When CP concentrations were above 100% of OM, increases in gain were low because those supplements provided low levels of supplemental energy. Change in gain tended to be related to supplemental CP intake (Figure 5), but the relationship was quite variable. When molasses only was fed, gains were either decreased or increased only slightly. When NPN was added, gains were increased generally, especially with the native forages. Use of meal or both meal and NPN tended to give more consistent positive responses. A CP intake of .1% of BW was required to ensure that gains would be increased by supplements.

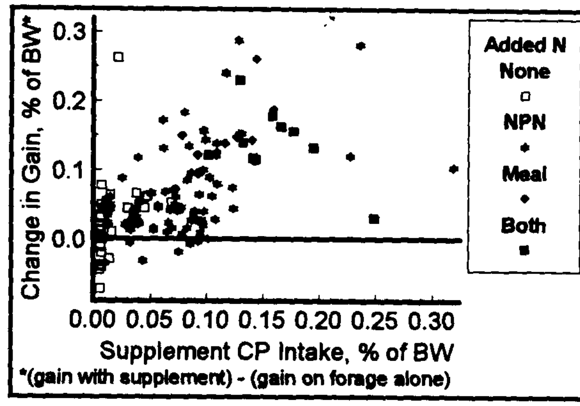


Figure 5. Change in daily gain due to feeding liquid supplement vs intake of supplemental crude protein (CP).

<u>Forage intake responses to liquid supplements</u>

Experiments with harvested forages were examined separately because they included forage intake data. The 44 comparisons with harvested forages showed similar gain responses to supplement (Figure 6) as did those with the entire data base (Figure 2). With low-quality forages, there was a greater gain response to supplementation with harvested than with grazed forages. This difference in response between grazed and harvested forages may be due to variability in forage availability among experiments when forages are grazed, thus causing more variable responses to supplements. Forage intake was either increased or decreased by liquid supplement (Figure 7), and the nature of the response was related to intake of forage fed alone. When intake fed alone was less than 1.75% of BW, supplements containing added nitrogen increased forage intake in almost all cases. A greater response in forage intake was seen when nitrogen was added to liquid supplements

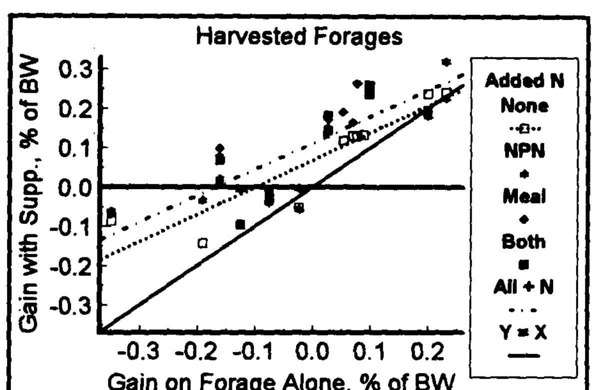


Figure 6. Daily gain on forage with liquid supplement vs gain on forage when fed alone.

than when molasses alone was fed. When intake fed alone was greater than 1.75% of BW, however, all supplements decreased forage intake. Concentration of CP in the supplement (when less than 60%) was related to forage intake change (Figure 8); on average, intake was increased by supplement when supplement CP was greater than about 25% of OM.

Change in intake due to liquid supplements was related to forage DOM:CP ratio (Figure 9) in the same manner as it was with dry supplements (Moore and Kunkle, 1995); when forage DOM:CP ratio was < 7 (balanced), all supplements decreased intake, but when the ratio was > 7 (unbalanced), the effect was inconsistent. The equations used to estimate effects of dry supplements on forage intake in the model component described by Moore and Kunkle (1995) were applied to the harvested forages in the liquid supplement data base (Figure 10). All comparisons were included except for those in which supplement CP concentration was less than 3 or greater than 80% of OM. No other limits (Moore and Kunkle, 1995) were applied. For the 35 remaining comparisons, there was close agreement between observed and predicted values. When change in forage intake was plotted against liquid supplement intake (Figure 11), the relationship was nearly identical to that with dry supplements (Moore and Kunkle, 1995); when forage DOM:CP ratio was < 7, intake was always decreased by supplement, but when it was > 7, intake was both increased and decreased. These data suggest that there is no obvious inherent difference between liquid and dry supplements in their effects on forage intake.

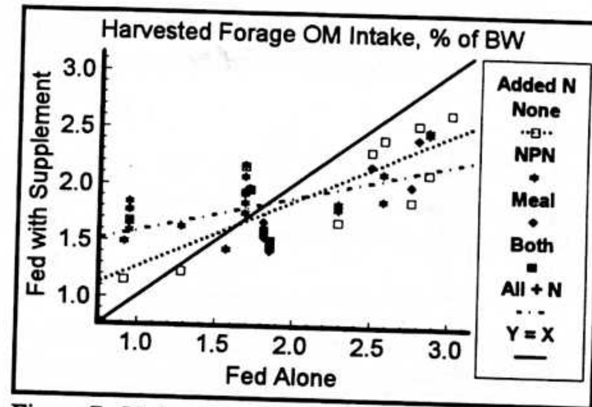


Figure 7. Voluntary organic matter (OM) intake of forage when fed with liquid supplement vs intake of forage when fed alone.

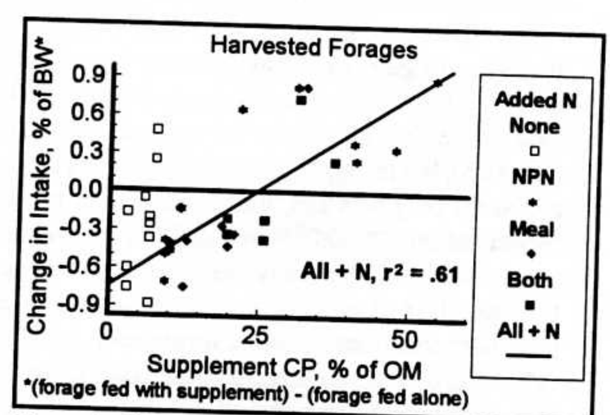


Figure 8. Change in voluntary organic matter (OM) intake of forage due to feeding liquid supplement vs supplement crude protein (CP) concentration when less than 60%.

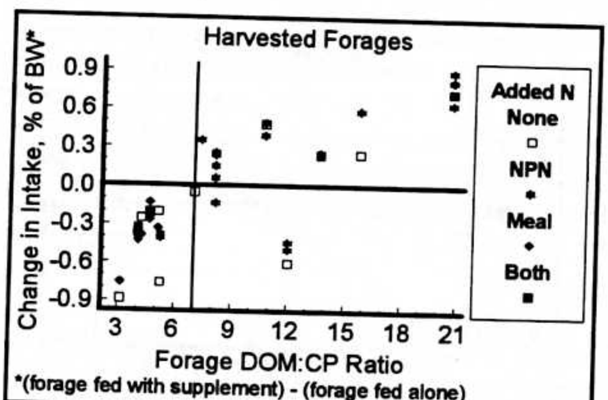


Figure 9. Change in voluntary organic matter (OM) intake of forage due to feeding liquid supplement vs the ratio of digestible OM (DOM) to crude protein (CP) in forage.

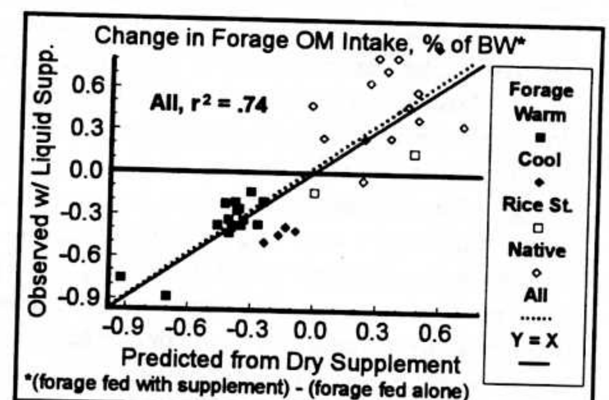


Figure 10. Observed change in voluntary organic matter (OM) intake of forage due to feeding liquid supplements vs the change in forage intake predicted by equations derived from the dry supplement data base.

Change in gain vs. change in intake

Among all the harvested forages, only 37% of the variation in change in gain due to feeding liquid supplements was accounted for by change in forage intake (Figures 12 and 13). Part of the remaining variation may have been due to whether the change in intake was positive or negative, the forage DOM:CP ratio (Figure 12), and the type of supplement (Figure 13). When the change in forage intake was positive, forage DOM:CP ratio was > 7 (unbalanced), and the change in gain was positively related to the change in intake. In this case, there was little effect of supplemental nitrogen source on the relationship between change in intake and change in gain. When the change in intake was negative, however, the change in gain was related to DOM:CP ratio and the source of nitrogen. When DOM:CP ratio was < 7 (balanced), the increase in gain was greatest when meal or both meal and NPN were added to the supplements compared to that when only molasses or molasses-NPN were fed. These data suggest that when forage quality is low (i.e., low voluntary intake when fed alone, and unbalanced DOM:CP ratio), liquid supplements will increase both forage intake and gain, but gains may still be low or even negative. In contrast, when forage quality is high (i.e., high voluntary intake, and balanced DOM:CP ratio), liquid supplements will decrease intake generally, but will increase gains if the supplement contains meal or a combination of meal and NPN.

Both the dry and liquid supplement data bases demonstrated the complex nature of the relationships between forage quality and type and level of supplement. Because of the many interactions, it is difficult to make general recommendations on the expected effects of supplements on animal response. Mathematical equations that describe the effects and interactions may, therefore, be of value in models that predict animal performance when supplements are fed to animals grazing or fed forages.

**Multiple Regression Equations to Predict Effects of Liquid Supplements**

The liquid supplement data base was used to generate multiple regression equations using the procedure described by Brant (1993) with the dry supplement data base. When comparisons included in the analysis were limited to those that include forage CP

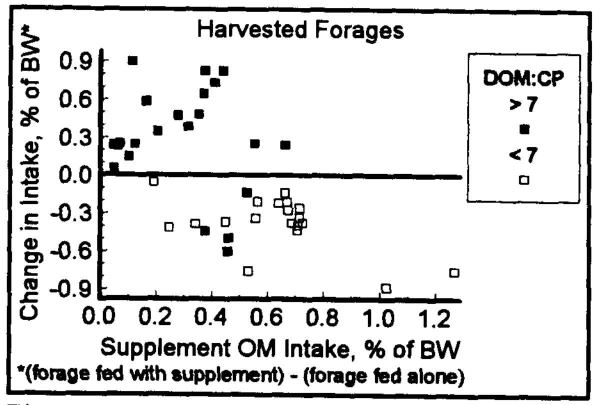


Figure 11. Change in voluntary organic matter (OM) intake of forage due to feeding liquid supplement vs intake of supplement; forages are classified by their ratio of digestible OM (DOM) to crude protein (CP) ratio.

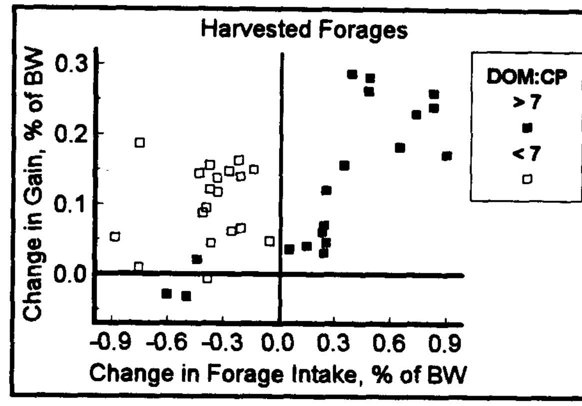


Figure 12. Change in daily gain vs change in voluntary organic matter (OM) intake of forage, both due to feeding liquid supplement; forages are classified by their ratio of digestible OM (DOM) to crude protein (CP).

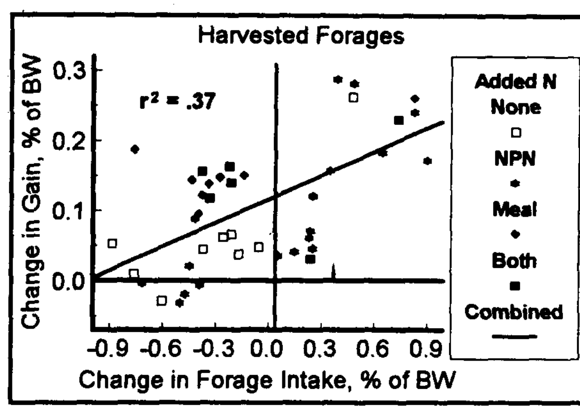


Figure 13. Change in daily gain vs change in voluntary organic matter (OM) intake of forage, both due to feeding liquid supplement, according to the type of supplement.

concentrations, there was a total of 38 observations for harvested forages and 86 observations for the combined grazing and harvested data set. The equations include variables that often are available from research, and could be available under practical conditions from forage testing programs and(or) historical data. Abbreviations used (and ranges of values in the data base) are:

FI = forage OM intake when fed alone, % of BW (.91 to 3.01)
CFI = change in forage OM intake due to supplementation, % of BW (-.88 to .90)
SI = supplement OM intake, % of BW (.03 to 1.27)
FCP = forage CP, % of OM (2.4 to 18.7)
SCP = supplement CP, % of OM (3.0 to 179.5)
FDOMCP = forage DOM:CP ratio (3.1 to 20.8)
SME = supplement ME, Mcal/kg OM (1.4 to 3.2)
MCP = mixed diet CP, % of OM (3.7 to 20.9)
SPI = supplement CP intake, % of BW (.005 to .32)
GNA = daily gain when fed forage alone, % of BW (-.35 to .28)
CGN = change in daily gain due to feeding supplement, % of BW (-.07 to .29)
NIT = type of added supplemental N (1= none, 2 = NPN, 3 = meal, 4 = both)

In the harvested forage data base, the equation for estimating change in forage intake was:

$$CFI = -2.39 + 2.86*FI - .539*FI^2 - .325*SI - .0755*FCP + .171*FDOMCP - .123*FDOMCP*FI + .0121*SCP*SI$$

$$R^2 = .93,\ RMSE = .14\ \%\ of\ BW$$

The RMSE was less than that for the CFI equations derived from the dry supplement data base (Moore and Kunkle, 1995). The value of .14 % of BW indicates that the equation estimates the change in forage intake within plus or minus .84 lb/d for a 600 lb heifer.

In the harvested forage data base, the equation for change in gain, as % of BW, using all variables (CGNha) was:

$$CGNha = .576 + .149*CFI + .0717*CFI^2 - .0277*GNA + 1.02*GNA^2 + 2.71*SPI - 5.84*SPI^2 - .516*SME + .108*SME^2 - .0606*FDOMCP*SPI - .000566*NIT*SCP$$

$$R^2 = .94,\ RMSE = .025\ \%\ of\ BW$$

An RMSE of .025 % of BW indicates that change in gain is estimated within plus or minus .15 lb/d for a 600 lb heifer. A major input in the above equation was CFI. Because CFI values were not available in the grazed forage data base, it was omitted from the analysis of the harvested forage data base; the revised equation for change in gain (CGNhb) was:

$$CGNhb = -.138 - 1.44*GNA + 2.21*SPI - 8.18*SPI^2 + .0179*FCP - .00111*FCP^2 - .000197*NIT*SCP + .0362*FCP*SPI + .164*FCP*GNA$$

$$R^2 = .89,\ RMSE = .033\ \%\ of\ BW$$

An RMSE of .033 % of BW indicates that change in gain is estimated within plus or minus .20 lb/d for a 600 lb heifer. The difference in RMSE values suggest that information on change in forage intake adds to the accuracy of predicting change in gain.

When the combined data set was analyzed, CFI and variables based on forage digestibility were not included in equations, and the equation for change in gain (CGNc) was:

$$CGNc = .0783 - .153*GNA + 1.39*GNA^2 - .0854*NIT + 4.83*SPI - 8.52*SPI^2 - .0106*FCP - .00910*SCP - .634*NIT*SPI + .00509*NIT*SCP + .00475*NIT*FCP - .0311*SCP*SPI + .000770*SCP^2*SPI^2$$

$R^2 = .85$, RMSE = .032 % of BW

The RMSE for the equations based on the combined data set (CGNc) was about the same as it was for the harvested data set when CFI values were omitted (CGNhb). In general, the same variables appeared in both equations, but the equations differed markedly in the main effects and interactions which were included. The differences between the two equations demonstrate clearly that empirical equations such as these may be specific to the data set on which they were developed. It is necessary to validate such equations under the conditions in which they will be applied before they can be used with confidence.

The equations described above estimate CHANGES in forage intake or daily gain due to feeding supplements. The low errors associated with the equations suggest that changes in forage intake and gain can be predicted within acceptable degrees of accuracy by using measures of intake or gain when forage is fed alone, data on composition and nutritive value of forage and supplement, and interactions among these variables. Different equations may be needed, however, for different types of forages and supplements.

In each equation, actual data on forage quality, either as intake of forage fed alone or gain on forage when fed alone, are key variables. In developing practical models that predict livestock performance, it will be essential to input estimates of forage quality and nutritive value. Such information may be obtained from forage testing programs if the results are applicable to the conditions where they will be applied.

### Implications

1) Voluntary forage intake may be either increased or decreased by the feeding of dry and liquid supplements; factors having general effects on the change in forage intake were:
   a) forage DOM:CP ratio for both dry and liquid supplements:
      i) when DOM:CP was balanced (< 7), supplements almost always decreased forage intake.
      ii) when DOM:CP was between 7 and 12, intake was both increased and decreased by supplements.
      iii) when DOM:CP was very unbalanced (> 12), all types and levels of supplements increased forage intake.
   b) forage intake level when fed alone (examined with liquid supplements only):
      i) when forage intake was > 1.75 % of BW, supplements decreased forage intake.
      ii) when forage intake was < 1.75 % of BW, supplements almost always increased forage intake.
   c) supplement intake level: forage intakes were decreased by both dry and liquid supplements when supplement intake was > .8 (up to 1.3) % of BW.
   d) supplement CP concentration: forage intake was increased when liquid supplement CP was > 25% of OM.

2) The ME concentration of a mixed forage plus concentrate diet may be greater than or less than expected (examined with dry supplements only; Moore and Kunkle, 1995); factors having general effects on the deviation from expected ME concentrations were:
   a) supplement intake level:
      i) when < .8 % of BW, diet ME concentration was either greater or less than expected.
      ii) when > .8 (up to 1.3) % of BW, diet ME concentration was always less than expected.
   b) forage DOM:CP ratio:
      i) when DOM:CP ratio was balanced (< 7), diet ME was almost always less than expected.
      ii) in all cases when diet ME was greater than expected, DOM:CP ratio was unbalanced (> 7).

3) Daily gains generally, but not always, were increased by feeding liquid supplements:
   a) when a source of N was added, gains were greater than when molasses alone was fed.
   b) when supplemental CP concentrations were above 15 % of OM, gains were almost always increased.
   c) when supplemental CP intake was greater than .1 % of BW, gains were always increased.

4) When forage quality was low (i.e., low voluntary intake when fed alone, and unbalanced DOM:CP ratio), liquid supplements increased both forage intake and gain, but gains were still low or even negative; in contrast, when forage quality was high (i.e., high voluntary intake, and balanced DOM:CP ratio), liquid supplements decreased forage intake generally, but increased gains if the supplement contained meal or a combination of meal and NPN.

5) The data examined in this paper suggest that there is no obvious inherent difference between liquid and dry supplements in their effects on forage intake.

6) Multiple regression equations may describe the complex interactions between forage quality and supplement type and level; these equations may not be valid, however, outside the bounds of the data set on which they were developed, and they should be used with caution until they have been validated.

7) Practical forage-livestock feeding models should include equations that describe the effects of supplement type and level on voluntary forage intake, deviation from expected ME concentration of mixed diets, and(or) daily gains; research must continue to develop practical methods of estimating the inputs to such models, especially the quality and nutritive value of grazed forages.

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