

Effects of nitrogen, phosphorus and sulfur on the yield, growth and quality of canola (Brassica napus L.)

by Gregory B Popove

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Agronomy

Montana State University

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Abstract:

The recent advent of canola production in the United States has underscored the need for current agronomic guidelines for optimal production. Although much research information from around the world pertaining to nutrient response of canola (spp. Brassica napus) has been disseminated, the soil and environmental conditions, as well as the production practices in Montana and the Intermountain Northwest area are sufficiently unique as to warrant further research.

Three varieties, Westar and two from the Intermountain Canola Company: IMC-01 and IMC-129 were tested at three locations in Montana. The Bozeman and Fairfield trials were irrigated and the Moccasin site was dryland. Eight treatments consisted of: a non-fertilized check, a standard application, and six experimental rates of nitrogen (N), phosphorus (P) or sulfur (S) respectively. Measured variables were: seedling vigor, date of first-flower, date of end-of-flower, maturity date (swath date), seed yield, 1000-seed weight, oil content and lodging score. Soil samples were taken to a depth of 1.2 m prior to fertilizer application.

Results suggest significant effects between applied nutrients and most measured variables. Curvilinear analysis of nitrogen-yield response curves indicates a linear response at the highest levels of fertilization at the flood-irrigated location (Fairfield). Some variety-treatment interactions were observed. Optimum nutrient application levels appeared to produce higher stand counts and plant vigor, as well as promoting wider plant-branching to compensate for low stand densities. Over-all response of canola to N was greater than to S and P. Higher moisture levels appeared to alter the variety-yield ranking at some locations. Yield was significantly affected by fertilizer treatments, particularly N, and by variety. Oil content was generally correlated negatively with N at higher fertility levels and positively correlated at lower soil nutrient levels.

This study supports previous studies which indicate a different fertilization profile is required for canola than for cereal grains. Canola generally has a higher requirement for N than cereal grains, while response to P is often less. Phosphorus response can differ due to the amount of less-labile P which may be present at significant levels resulting from several years of P fertilization. Sulfur response may be highly variable due to differences in the sulfate reserves in the subsoil profile.

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A thesis submitted in partial fulfillment
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APPROVAL

of a thesis submitted by

Gregory B. Popove

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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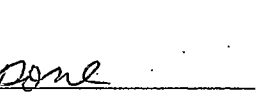
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## ABSTRACT

The recent advent of canola production in the United States has underscored the need for current agronomic guidelines for optimal production. Although much research information from around the world pertaining to nutrient response of canola (spp. *Brassica napus*) has been disseminated, the soil and environmental conditions, as well as the production practices in Montana and the Intermountain Northwest area are sufficiently unique as to warrant further research.

Three varieties, Westar and two from the Intermountain Canola Company: IMC-01 and IMC-129 were tested at three locations in Montana. The Bozeman and Fairfield trials were irrigated and the Moccasin site was dryland. Eight treatments consisted of: a non-fertilized check, a standard application, and six experimental rates of nitrogen (N), phosphorus (P) or sulfur (S) respectively. Measured variables were: seedling vigor, date of first-flower, date of end-of-flower, maturity date (swath date), seed yield, 1000-seed weight, oil content and lodging score. Soil samples were taken to a depth of 1.2 m prior to fertilizer application.

Results suggest significant effects between applied nutrients and most measured variables. Curvilinear analysis of nitrogen-yield response curves indicates a linear response at the highest levels of fertilization at the flood-irrigated location (Fairfield). Some variety-treatment interactions were observed. Optimum nutrient application levels appeared to produce higher stand counts and plant vigor, as well as promoting wider plant-branching to compensate for low stand densities. Over-all response of canola to N was greater than to S and P. Higher moisture levels appeared to alter the variety-yield ranking at some locations. Yield was significantly affected by fertilizer treatments, particularly N, and by variety. Oil content was generally correlated negatively with N at higher fertility levels and positively correlated at lower soil nutrient levels.

This study supports previous studies which indicate a different fertilization profile is required for canola than for cereal grains. Canola generally has a higher requirement for N than cereal grains, while response to P is often less. Phosphorus response can differ due to the amount of less-labile P which may be present at significant levels resulting from several years of P fertilization. Sulfur response may be highly variable due to differences in the sulfate reserves in the subsoil profile.

# CHAPTER 1

## INTRODUCTION

Oilseed Rape or Rapeseed, otherwise described scientifically as *Brassica napus* L., is a relatively recent addition to American agriculture as a source of edible oil. Newer varieties, described as double-low types (low glucosinolate and low erucic acid) are widely referred to as *Canola* in North America.

This study was conducted to document nutrient requirements and responses for canola in western Montana soils. Although considerable information exists from Canada and other countries, soil and climate conditions differ significantly between Montana and other regions. Canadian soils are almost exclusively glacial in origin, and much of Montana is non-glacial. Day length can vary by as much as two hours per day in June, between southern Montana and northern Alberta. The climate of Montana is generally warmer and drier than most of the major canola-growing areas of Canada, therefore the possibility for unique production problems may occur.

The hypothesis to be tested in this study is that conditions in Montana are sufficiently different from other canola-growing areas, and this will require a set of production recommendations for growing canola which is unique for the region.

Special attention was paid to identify possible problems which may have appeared, that could be reflected in future canola production. The canola test plots were managed with typical canola production practices. Pest control guidelines were

followed, in that pesticides were not applied when pest counts were below economic threshold levels as defined by the Intermountain Canola Company's agronomic production guidelines. No fungicide and/or insecticide seed treatments were used as often happens in U.S. canola production at this time. Irrigation water was applied in quantities and timing in accordance with typical field practices. Herbicide application was restricted to grass control with POAST (sethyoxydim) and canada thistle eradication with STINGER (clopyralid) where infestations were substantial or severe. A particular focus for the study was for sulfur response, because it can often be more important in canola than in cereal grain production. Sites were chosen which were candidates for possible sulfur deficiency. Potassium was not included in this study. The test sites are generally not K-deficient, and few studies in the past have shown K-response on these types of soils.

The use of nitrogen, phosphorus and sulfur at 0x, 1x and 2x rates was seen as an effective way to analyze linear and curvilinear response. This type of information is useful in establishing fertilization guidelines for specific cropping situations, and identifying nutrient deficiencies.

It is hoped that all the methods employed in this study cannot only test the hypothesis, but can add to the knowledge-base for canola production. Effects observed in this study may also lend support to further research in canola production.

# CHAPTER 2

## LITERATURE REVIEW

### Nitrogen

Canola requires higher amounts of nitrogen (N) than most other crops (Soper, 1971), and canola continues to respond to increasing levels of applied nitrogen until soil nitrate levels are above 100 kg $ha^{-1}$. In some soils, canola has responded to N levels of up to 200 kg $ha^{-1}$ (Nuttall et al., 1987; Lewis and Knight, 1987; Bailey, 1990). Increased N rates have been shown to promote lodging also (Yusuf and Bullock, 1993; Sheppard and Bates, 1980).

The effects of N-deficit in the canola plant have also been explored. Leaf senescence in canola was related to very low soil nitrogen levels (Rood et al., 1984). In the first year of a two-year study, nearly all N was depleted from the upper soil layers, and rapid leaf-loss was observed. Slightly higher N levels in the second year resulted in much-reduced leaf-loss at maturity. This is a possible field indicator of low N status in the soil.

The influence of N on canola's quality factors was shown to be substantial by several researchers. Protein content in canola generally increases with N availability (Henry and MacDonald, 1978; Sheppard and Bates, 1980; Nuttall et al., 1987). Since N is

a major component of all proteins, protein synthesis may be inhibited without adequate N and other nutrients (Finlayson et al., 1970).

Although the inverse relationship between N levels and oil content has been well described (Bhatty, 1964; Allen and Morgan, 1972; Sheppard and Bates, 1980), a mechanism for this phenomenon was better-elucidated by Diepenbrock and Geisler in 1981. Chlorophyll levels and chloroplast characteristics in canola leaves were seen to be influenced by available N. Chlorophyll levels were reduced only under extreme N deficiency, but galactolipid levels were highly correlated with N levels. The production of linolenic acid (C18:3) rose in proportion to available N until levels of latent, moderate deficiency were reached, where it plateaued. As levels of N rose to what was optimal for growth and above, levels of galactolipids and linolenic acids fell sharply. This was partially explained by changes in the fine structure of the thylakoid membranes in the chloroplasts under high N levels.

Water-use efficiency (WUE) was observed to increase with moderate (100 kg $ha^{-1}$) and high-rate (200 kg $ha^{-1}$) additions of N on canola (Taylor et al., 1991). The high N rates reduced oil concentration in seed, but increased overall oil yield.

Response of canola to other nutrients was slight in a study by Sheppard and Bates (1980), but N elicited the greatest yield response. Leaf concentrations of N varied considerably with the level of treatment. Band-placement fertilizer applications increased yields significantly over other types of placement.

## Phosphorus

Canola requires phosphorus (P) in levels comparable to cereal grains when grown on P deficient soils (Soper and Racz, 1963). It has often shown a lesser P response than many other crops (Soper, 1971) in soils with higher levels of reserve-P (less-extractable phosphate). Soils that require P amendment for cereal grains often have adequate P for canola. There appears to be a better P extraction mechanism in canola roots than in other plants.

Grinsted, et al. (1982) found that *Brassica napus* caused an acidification of its rhizosphere by as much as 2 to 4 pH units in P deficient soils. This decrease in pH facilitated a tenfold increase in P uptake by the plant. Phosphatase activity appeared to correlate to root density (Hedley et al., 1983). In soils sensitive to pH change, preferential uptake of anions contributed to the acidification of the rhizosphere. Acid levels below 5.5 can have a detrimental effect on yield (Edwards, 1991) however, and annual applications of P are needed to alleviate this condition.

The role of plant metabolism on P influx into plant roots was tested with a protein synthesis inhibitor and a metabolic uncoupler (Schjørring and Jensén, 1984b). The concentration of P in roots appeared to vary 60 to 70% due to the influence of disabled plant metabolic factors in this experiment. Influx at low P concentrations and efflux at high levels were significantly reduced in canola with the addition of these inhibitors. From these data it appears that *Brassica napus* utilizes active-transport processes for P uptake in its roots.

Shoot/root fresh weight ratios were strongly influenced by the external P supply in a study by Schjørring and Jensén (1984a). The shoot/root ratio was highest at low P levels. There was a near-linear relationship between P concentration in the root zone and an increased shoot-to-root ratio existed at low-to-intermediate levels. As higher P levels were reached, the increase in shoot/root ratio was less pronounced.

From past research, it seems useful when growing canola, to allow for the "soil phosphorus reserve" of less extractible P when gauging P requirements for a crop. This might be accomplished with soil tests that measure the less-labile forms of phosphorus such as "weak-Bray and strong-Bray" tests, or calibration of current tests. Continued P fertilization under cereal grain production may lead to a buildup of usable P for a subsequent canola crop.

## Sulfur

S requirements are higher for canola than for most other crops and have been established about 25-35 kg $ha^{-1}$ (Nyborg, 1974). Sulfate ($SO_4^{=}$) is the chief form taken up by the plant (Thompson et al., 1986), and is required for chlorophyll, protein synthesis and for production of volatile oils that constitute glucosinolates (Marschner, 1986).

Nitrogen-to-sulfur ratios in canola have been optimal at 7:1 (Janzen and Bettany, 1984). Seed yields were significantly reduced when the ratio exceeded 7, and excess S accumulated in stems and leaves when the ratio was below 7.

Subsoil reserves of S appeared to serve as both a "reserve" and a "sink" for sulfate in soils in a study by Castellano and Dick (1991). Sulfate and residual S levels in soil appeared to decrease in spring with downward leaching, and increase later in the season with upward soil water movement driven by evapo-transpiration. Another S-reserve, Carbon-bonded S in organic matter did not appear to fluctuate seasonally, or in response to cropping. These phenomena qualify soil testing of available soil S to allow for subsoil S reserves and net seasonal water movements in the soil profile.

The negative effects of excessive S accumulations have been studied recently. High rates of S fertilization that exceed 100-200 $\mu g\ g^{-1}$ (ppm) can increase oil content in canola seed and raise glucosinolate concentrations (Booth et al., 1991), while decreasing yield (Mailer, 1989). A depression in oil content was seen in a study by Wetter et al. (1970). Inorganic sulfate accumulations were seen to be higher in pods of double-low (low glucosinolate and low erucic acid) type canola than what was observed in single-low (low erucic acid) varieties (Zhao et al., 1993). This was explained by the hypothesis that the pod walls are the site of biosynthesis of seed glucosinolate, and blocking of this pathway in low glucosinolate varieties (originally Bronowski var.) results in the accumulation of inorganic sulfates (Josefsson, 1971).

Sulfate uptake into canola plasma-membrane vesicles was strongly influenced by an imposed pH gradient (Hawkesford et al., 1993). Acidifying the solution outside the membrane to pH 5.0 caused a twofold increase in sulfate uptake over solutions of pH 6.5.

Sulfur appears to be a critical nutrient for canola, required in higher amounts than for cereals. Nitrogen and sulfur are required by each other for optimal utilization, and excessive levels can lead to unfavorable growth and seed quality characteristics.

## Soil Test Correlation

The effects of nitrogen and P treatments had no significant interaction in a sixteen-year study of canola seed and straw yield correlated with soil tests (Nuttall et al., 1992). The greatest variability in yield was due to yearly fluctuations of total seasonal precipitation and mean daily temperature. Yield was negatively correlated to mean daily temperatures, and positively correlated to total seasonal precipitation. This effect was thought to contribute significantly to the soil test-to-yield correlations of $r^2$=0.58 for N and $r^2$=0.46 for P.

# CHAPTER 3

## MATERIALS AND METHODS

### Experimental Design

This study was conducted as a split-plot design, with three varieties as main plots, and eight fertilizer treatments as subplots. The experiment was conducted at three locations for two years. The three varieties were IMC-01, IMC-129 and Westar. The fertilizer treatments consisted of a no-fertilizer check, a normal-rate application, and 0x, 1x, and 2x rates of nitrogen, phosphorus and sulfur respectively. Each location was divided into four blocks.

### Fertilizer

Fertilizer types were the same at all sites and in both seasons. Nitrogen was supplied by ammonium nitrate (34-0-0) in pelleted form, phosphorus was provided by monocalcium phosphate (0-45-0), and ammonium sulfate (21-0-0-24) was the source of sulfur. Some additional nitrogen application was effected with the sulfur applications (21%N), and amounted to about 19 kg $ha^{-1}$ (Table 1).

**Table 1. Fertilizer Treatments: N-P-K-S (kg ha$^{-1}$)**

| | Treatments | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 check | 2 normal | 3 high N | 4 no S | 5 high S | 6 no P | 7 high P | 8 no N |
| **Dryland** | 0-0-0-0 | 56-22-0-22 | 112-22-0-22 | 56-22-0-0 | 56-22-0-45 | 56-0-0-22 | 56-45-0-22 | 19-22-0-22 |
| **Irrigated** | 0-0-0-0 | 112-22-0-22 | 168-34-0-22 | 112-34-0-0 | 112-34-0-45 | 112-0-0-22 | 112-67-0-22 | 19-34-0-22 |

## Locations

The three Montana test locations consisted of a dryland site (Moccasin) and two irrigated sites (Bozeman and Fairfield). Site selection criteria were for a diversity of environmental and management factors in the major canola-growing regions of Montana, as well as for soils that were expected to have lower sulfate levels. Two of the three sites were characterized by soils with a gravely, glacial outwash parent material (Fairfield and Moccasin), which differ significantly from glacial-till type parent materials that have often been shown to contain higher sulfate levels. The soil at the Bozeman site developed from loess parent material and is similar to other soils in the area, which have shown response to S by cereals and forages.

## Soil Sampling and Testing

Soil was sampled at: 0 to 15 cm, 15 to 30.5 cm, 30.5 to 61 cm and 61 to 122 cm. All samples were collected before spring planting and analyzed at the Western Testing Laboratory at Great Falls Montana. Phosphorus was determined by Olsen bicarbonate test, $NO_3$ -N by CaOH extraction (.2%) with chromotropic acid for colorimetry and S by ammonium acetate (.5N) with acetic acid (.25N) extraction. The pH at all locations were in the 7.4 to 7.5 range and are known to have moderate to high potassium content.

Equipment consisted of truck-mounted hydraulic soil probe that was used at all locations and for all soil depths.

## Varietal Descriptions

### Westar

Westar was developed at the Agriculture Canada Research Station at Saskatoon, Saskatchewan, Canada and first licensed for use in 1982. The variety was obtained from a single plant selection in the $F_4$ generation of the cross: ((SD x 568-2895) $F_3$ x Midas) $F_2$ x Tower. It was selected for oil and meal quality characteristics, early maturity, high seed yield and standability (lodging-resistance).

The plant height, lodging resistance, protein content and disease reaction were comparable to most previously-established varieties. Yield, oil content, glucosinolate levels and maturity were slightly better than most other varieties licensed at the time of its introduction (*Source: Agriculture Canada description of variety dated 8-6-1982, issued by Secan Association 3-15-1994*).

### IMC-01

IMC-01 variety (Sunola 001) was developed by the DNA Plant Technology Corporation in 1988. The line was selected from an uncharacterized, private germplasm collection for its low-linolenic acid (C18:3) content. These oils have desirable characteristics such as higher oxidative stability and reduced odor development when heated. The yield of this variety is described as 80% of Westar under dryland conditions and 90% under irrigation. Maturity is about 8 days later than Westar, and lodging resistance is better than Westar under irrigated conditions. Plant height is about 1 - 1.3 m, and it has moderate resistance to blackleg (*Phloma lingam*). Leaves are narrower than Westar and have a distinctive inward curling (*Source: undated variety description bulletin, Intermountain Canola Company*).

**IMC-129**

This variety was developed by chemical mutagenesis from the Westar variety by the DNA Plant Technology Corporation in 1989. The line was self-pollinated and selected for high oleic acid (C18:1) for seven generations before breeder seed was distributed. IMC-129 appeared to be homogeneous and without morphological variation during the production of foundation seed. Maturity is about two days later, and the plant is about 5 cm. taller than Westar. The fatty acid profile differs in that it has about 15% more oleic acid than Westar, for a total of about 77% in the seed oil (*Source: excerpt from application for PVPA certificate, issued from IMC 2-16-93*).

## Planting

Seeding was carried out at all three locations with standard plot-seeding equipment. Canola seeds were weighed to obtain a seeding rate equivalent to 4 pounds per acre. This amount was calculated to be 2.2 grams per 100 $ft^2$ (9.29 $m^2$) plot, and was placed in paper envelopes for transport to the field and planting.

Fertilizer was applied in the field by several methods. At Moccasin, measuring scoops were prepared for N, P and S fertilizers that were dipped from a bulk supply. These measured amounts were poured into the planter cone-bins in the required number at each respective plot. At Fairfield, fertilizer was applied through drill-mounted hoppers that could be adjusted quickly at each plot to deliver the desired amount of each fertilizer treatment. Water was applied after seeding at this location in 1992 due to excessively dry soil conditions. At Bozeman, the required amount of each fertilizer was measured for each plot, and spread over the surface by hand as uniformly as possible. It was then worked into the soil to a depth of 5 cm.

## Harvesting

All plots were swathed prior to drying and threshing. At Moccasin, a plot forage harvester delivered acceptable swath-rows. Only the four central rows of the six-row plots were harvested to minimize edge-competition effects. The chosen method of swathing at the Bozeman location was hand-cutting and windrowing of the four central rows. Because of the inaccessibility of the Fairfield location by harvesting equipment, a smaller sample, 1.5 $m^2$ was taken for harvest. This sample was left in the field for several days drying, and then transported to a stationary threshing machine. At Bozeman and Moccasin, threshing was conducted with standard small-plot combines.

The grain samples were then cleaned with a stationary air separation cleaner. The air-choke setting and screen size were selected for the optimum balance of chaff removal and seed loss. This setting was not altered during the time when the entire lot of seed from a particular location was being cleaned. This procedure was used to minimize variability among individual seed samples within each location.

## Statistical Analysis

Variables were analyzed using analysis of variance, correlation and regression. These were completed with the MSUSTAT statistical analysis package developed at Montana State University, and with the Microsoft EXCEL application's analysis tools. Response to N, P and S were investigated using an orthogonal polynomial coefficient for equally spaced treatments.

## Description of Measured Variables

The variables measured in this study were: seedling vigor, date of flower initiation, date of flower cessation, date of seed color change (swathing date), grain yield, seed oil content, 1000-seed weight, and lodging scores. Measurement techniques did not differ appreciably between the two seasons, with the exception of seedling vigor measurements. A dry sample weight of seedlings was used the first year, and showed little significant variation, so an alternate method of scoring based on seedling height and density was employed in the second season.

These data were collected in the field or lab, and transcribed directly to a dBASE IV data file. All data transformations were calculated within the database.

### Seedling Vigor

In the 1992 season an attempt was made to correlate seedling dry weight to final yield. At the four leaf growth stage, a 30 cm sample from two rows of each plot was cut at ground level. The method employed for inter-plot sample selection was to visually select a location which was representative of the entire plot, and to cut the sample with clipping shears at ground level. Plants were sampled at the 4 to 5-leaf stage of development. This method was used due to high variability in plot density at some sites with differing emergence times. The samples were oven-dried at 100 $^{o}$C for 48 hours. The dry weights were recorded and later correlated with final yield seed weights, to determine yield potential estimates at the seedling stage.

In the second year of the study (1993), a different method was attempted due to the absence of a consistent correlation between seedling weights and final yield in the previous season. A visual vigor score was established from a composite of stand density rating and average plant height rating. Each factor was assigned a 0 to 5 score. The plots within the first quintile of plant density rankings at the site (thinnest stand or smallest

plant) were assigned a 0-value. The plots within the fifth quintile (highest at the location) received a 5. The two factors were combined for a maximum possible vigor score of 10. Plants were examined at the 4 to 5-leaf stage of development. This method was also chosen for its compatibility with agronomic field-evaluation situations.

**Flowering Dates**

The date at which the first flowers had appeared in approximately 5% of the visible canola racemes in each plot was recorded as date of flower initiation. It was then converted to a numeric variable expressed as days after seeding. All sites appeared to make the transition from bolting to bloom quite rapidly, so it is estimated that the visual observations of date of flower initiation are accurate to within 2 days.

The flower cessation measurement was determined by the time when approximately 95% of the canola racemes had ceased bloom of the terminal flower. The end of blooming did not occur as succinctly as did first-bloom, and required the determination of a mean date by estimation. These dates were also converted to numeric values expressed as days after seeding.

**Color Change**

This variable corresponds approximately to the date when canola is normally swathed, according to field guidelines established in Canada and the US. This is the approximate date when one-half of the canola seeds have turned from green to a brown-black color. Pods from the central racemes of several plants were collected at approximately one-third height from the base. If seeds from these samples were approximately one-half brown or black, the color-change date was recorded and converted to days after seeding. This measurement was the most time-critical, as the seed-ripening process occurs quite rapidly in canola and pod shattering often becomes a problem soon after ripening.

**Yield**

The final seed weight expressed as kilograms per hectare (kg $ha^{-1}$) was obtained from the harvested portion of each plot. In the Bozeman and Moccasin locations, the central four rows of the six plot rows were harvested to minimize edge effects. Due to practical considerations, the seed collection method differed slightly at the Fairfield location. A two-row sample, 2.44 m (8') in length was collected from the same relative position in each plot, except where growth in the target area was visibly atypical of the plot as a whole. In these cases, a representative sample was taken from an alternate location in the plot.

The samples were cleaned manually with a screen and an air-separator provided by the Plant, Soil and Environmental Science department of Montana State University. To maintain consistency, each sample was screened three times and air flow was adjusted for optimum chaff removal. The resultant sample weight was corrected for area to obtain a kg $ha^{-1}$ yield value.

**Oil Content**

The seed oil content was determined by nuclear-magnetic resonance (NMR) equipment in the seed laboratory at the Intermountain Canola facilities at Idaho Falls, Idaho. After seed weights had been determined, a subsample was removed and submitted to the laboratory for analysis. Oil content was expressed as percent (%) oil per seed by weight. The analysis also provided a complete profile of fatty-acid composition including: C14:0, C16:0, C16:1, C18:0, C18:1, C18:2, C18:3, C20:0, C20:1, C20:2, C22:0, C22:1, C24:0, C24:1 and the FDA-rating saturated fats.

**Seed Weight**

Seed density is expressed as weight in grams per 1000 seeds. A small-grain electronic seed counter was used. The counter was run until the seed count reached 250, sample was weighed and multiplied by 4 to obtain the 1000-seed weight variable.

## Lodging Score

The degree of lodging was expressed as a 0 to 5 score. Plots within which nearly all plants were flat to the ground received a score of 0, and plots with no visible bending of the stems received a score of 5. This effect was somewhat confounded by wind, heavy rains and lodging in adjacent plots. Lodging sometimes appeared to carry over into adjacent plots which may have affected some readings, giving some plots a higher than appropriate score. Very little lodging was observed at dryland sites, and this was probably due to lesser rainfall, which restricted biomass development. It was therefore necessary to evaluate the lodging score with these factors in mind, and scores tend to be relative to a single location. These factors may tend to make lodging comparisons between locations less valid.

# CHAPTER 4

## RESULTS AND DISCUSSION

### Seedling Vigor Measurements

Seedling vigor (Table 2) as measured by sampled dry weights in 1992 showed highly significant differences ($p<0.001$) due to treatments at Bozeman and Fairfield (Figs. 1&2), but results at Moccasin (Fig. 3) were not significant. The high N treatments appeared to be chiefly responsible for this effect.

**Table 2. Mean Squares from Analysis of Variance for 3 Canola Varieties in Combination with 8 Fertility Treatments for Seedling Vigor**

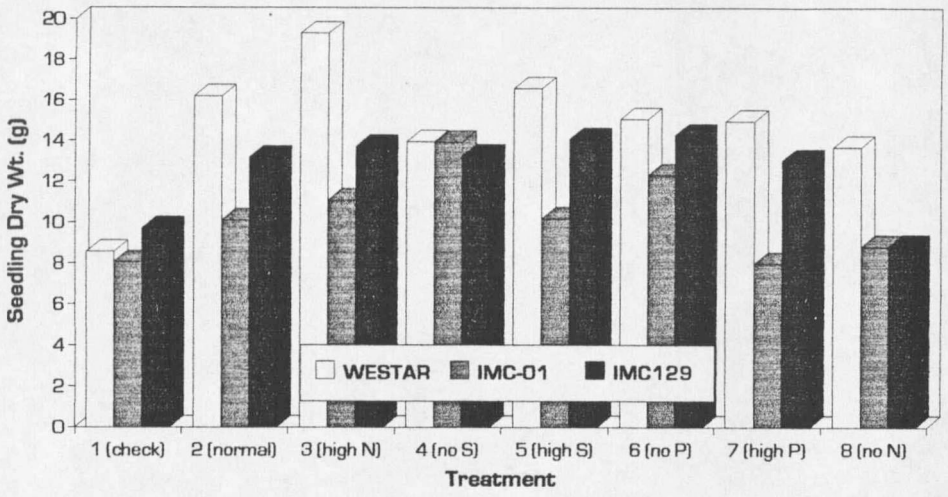
| | | Location/Year | | | | | |
|---|---|---|---|---|---|---|---|
| **Source** | df | Fairfield 1992 | Moccasin 1992 | Bozeman 1992 | Fairfield 1993 | Moccasin 1993 | Bozeman 1993 |
| Grand Mn. | - | 12.54 | 5.70 | 8.94 | 6.82 | 6.02 | 6.05 |
| Variety | 2 | 161.11** | 3.35 NS | 7.19* | 6.29* | 18.04 NS | 40.39 NS |
| Residual | 6 | 15.02 | 12.74 | 67.58 | 1.00 | 6.86 | 10.64 |
| Treatment | 7 | 48.56*** | 4.90 NS | 56.26*** | 4.51** | 2.42 NS | 4.93** |
| Trt. x Var. | 14 | 11.96 NS | 1.66 NS | 7.97 NS | 0.97 NS | 1.67 NS | 1.55 NS |
| Residual | 6 | 11.12 | 2.96 | 9.23 | 1.28 | 1.51 | 1.64 |

NOTE: *, **, *** significant at 0.05, 0.01, and 0.001 levels respectively.

Differences due to treatment were not significant at Moccasin (Fig. 6) in 1993, but were significant at the 1% level at Bozeman and Fairfield (Figs. 4&5). Withholding

sulfur generally appeared to reduce seedling vigor, and the addition of a higher S rate appeared to increase vigor, with the exception of Fairfield in 1992.

**Figure 1. Seedling Vigor Score - Fairfield 1992**




The differences due to variety in the 1992 season were significant at Bozeman ($p<0.05$) and Fairfield ($p<0.01$), and not significant at Moccasin. The high-sulfur treatment at Fairfield produced the highest mean seedling-vigor score. Differences due to variety were significant only at Fairfield, with the highest degree of contrast between IMC-01 and Westar. The Westar variety appeared to have the greatest degree of varietal variation. Treatment by variety interactions were not significant at any of the locations.

It appears that vigor measurements which utilize the shoot of canola seedlings are not a good predictor of final yield. Measurements which incorporate root weight may prove to be more reliable for this purpose, because a characteristic of Brassicacae is the

ability to store carbohydrate reserves in the root. These reserves may be much more significant as a predictor of final yield than any above-ground characteristics of the shoot.

**Figure 2. Seedling Vigor Scores - Bozeman 1992**

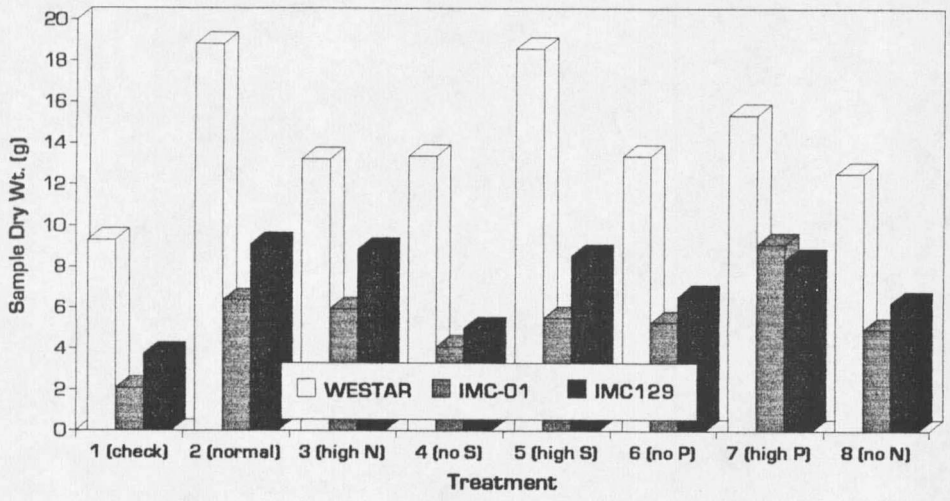



**Figure 3. Seedling Vigor - Moccasin 1992**

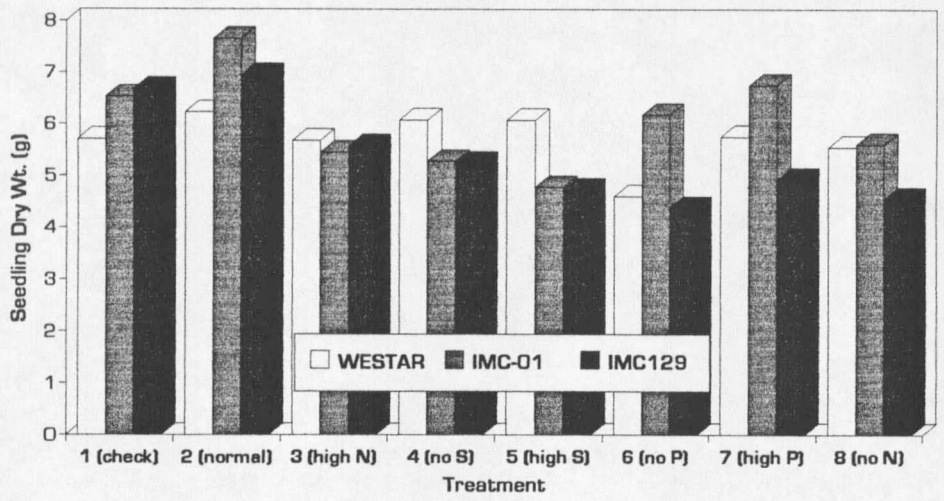


**Figure 4. Seedling Vigor Scores - Fairfield 1993**

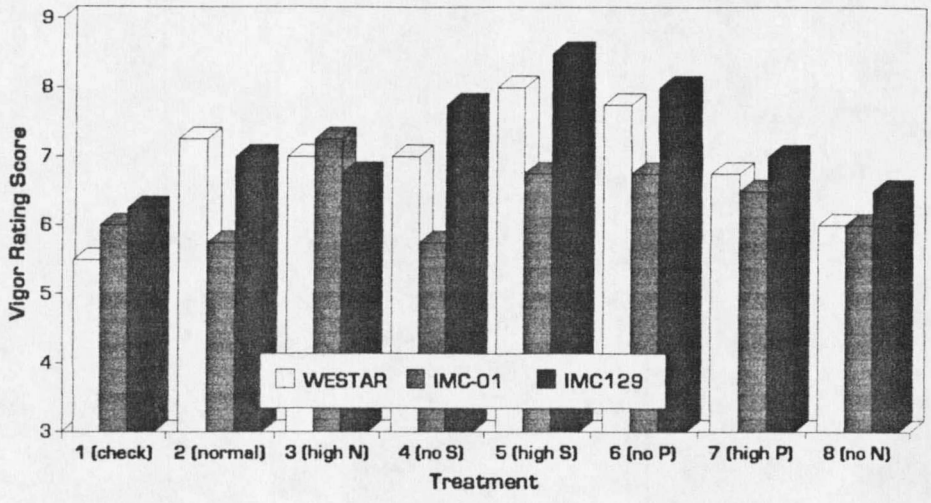



**Figure 5. Seedling Vigor Scores - Bozeman 1993**

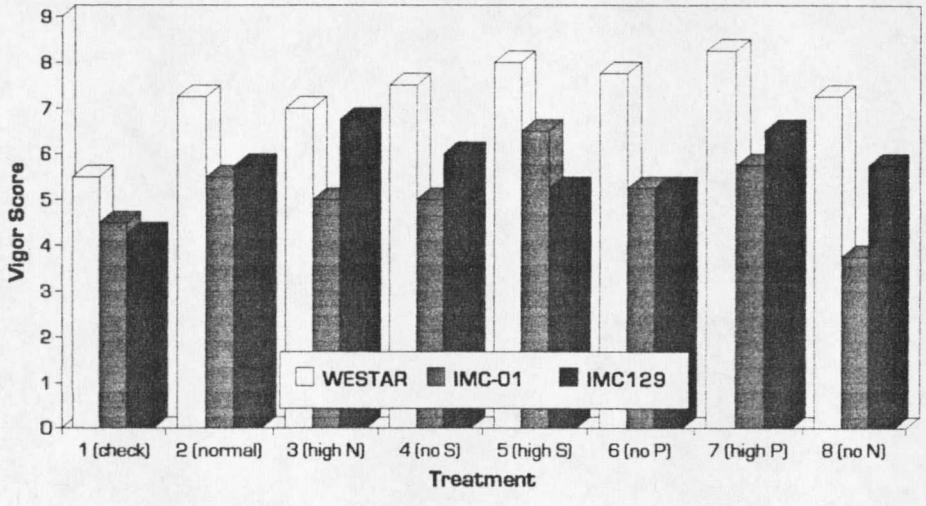
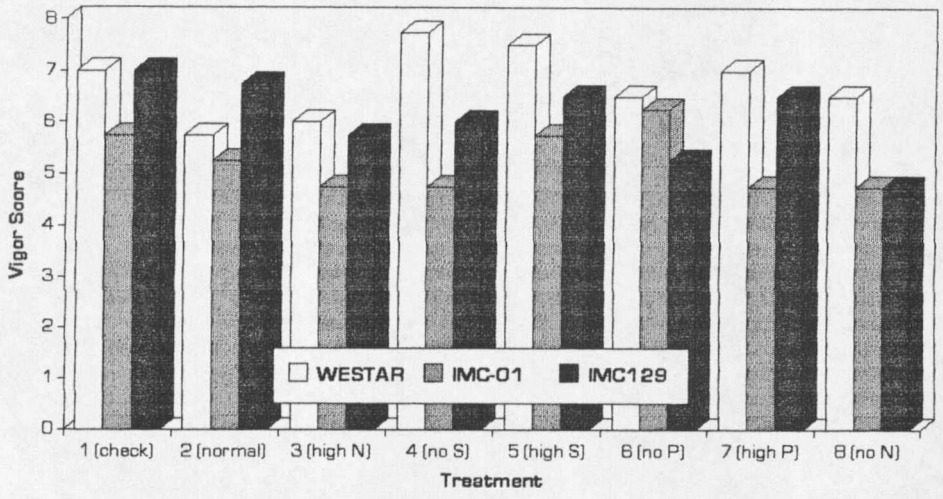


Figure 6. Seedling Vigor - Moccasin 1993




## Yield Response to Applied Nutrients

### Nitrogen Response

Nitrogen elicited the greatest yield response of any of the applied nutrients in this study. It showed a consistent, highly significant response at all locations and in both years of the study (Table 3). This concurs with many studies which report that canola is a heavy user of N (Batty, 1964; Allen, 1972; Henry and MacDonald, 1978).

The degree of linearity of the yield response to N was determined with a curvilinear contrast test. Mean squares for both linear and curvilinear (quadratic) response were obtained (Table 3) The most pronounced curvilinear yield response for N was observed at Bozeman 1993. The 2N rate effected a yield response over the null rate in lesser proportion than did the 1N treatment.

## Table 3. Mean Squares[a] of Linear and Quadratic[b] Contrasts for Yield (kg ha$^{-1}$)

| Source | df | Location/Year | | | | | |
|---|---|---|---|---|---|---|---|
| | | Fairfield 1992 | Moccasin 1992 | Bozeman 1992 | Fairfield 1993 | Moccasin 1993 | Bozeman 1993 |
| **Treatment** | 7 | 2966900 *** | 122420 *** | 1085400 *** | 1220300 *** | 1175600 *** | 2158000 *** |
| N linear | 1 | 9440100 *** | 218310 *** | 1806200 *** | 2342500 *** | 4486800 *** | 3175500 *** |
| N Quadratic | 1 | 362670 NS | 47689 * | 414960 ** | 341960 * | 48828 NS | 796320 *** |
| P linear | 1 | 311680 NS | 14900 NS | 641570 *** | 30745 NS | 25155 NS | 15965 NS |
| P Quadratic | 1 | 712620 ** | 85009 ** | 38828 NS | 13257 NS | 2.3472 NS | 13095 NS |
| S linear | 1 | 110980 NS | 1261.5 NS | 47082 NS | 23500 NS | 687490 *** | 109220 NS |
| S Quadratic | 1 | 486760 NS | 16745 NS | 59916 NS | 56168 NS | 14564 NS | 1335600 NS |
| All Treatments | 1 | 1016000 *** | 524500 *** | 4383600 *** | 5663700 *** | 2847700 *** | 10590*** |
| Residual | 2 | 191580 NS | 40610 * | 235140 * | 212800 * | 83629 NS | 540640 *** |
| Treatments x Variety | 14 | 365320 ** | 13235 NS | 53937 NS | 31602 NS | 17829 NS | 120320 * |
| Var.. x N linear | 2 | 242550 NS | 8453.4 NS | 150630 NS | 12971 NS | 25101 NS | 31097 NS |
| **Var. x N** Quadratic | 2 | 351830 NS | 16870 NS | 414960 ** | 9383 NS | 11095 NS | 13060NS |
| Var. x P linear | 2 | 95097 NS | 6997.2 NS | 3697 NS | 1513 NS | 16248 NS | 47293 NS |
| Var. x P Quadratic | 2 | 16973 NS | 36619 * | 9169 NS | 10652 NS | 19667 NS | 356250 ** |
| Var. . x S linear | 2 | 1012800 ** | 28122 NS | 12315 NS | 39834 NS | 13861 NS | 95714 NS |
| Var. x S Quadratic | 2 | 100360 NS | 21565 NS | 30559 NS | 29907 NS | 32805 NS | 148120 NS |
| All Varieties | 2 | 614150 * | 3879 NS | 111740 NS | 128910 NS | 12683 NS | 209270 * |
| Residual | 4 | 120400 NS | 11816 NS | 34313 NS | 4041 NS | 12053 NS | 155360 * |

[a] *, **, *** significant 0.05, 0.01, and 0.001 levels respectively.
[b] Quadratic contrast indicates a curvilinear yield response between 0, 1x and 2x treatments of each nutrient.

Soil tests did not reflect a high soil nitrate level in the top 61 cm, so the nonlinear response may have been due to other factors. This location was subjected to a moderately high insect infestation. Although the populations of fleabeetles (*Alticinae phyllotreta cruciferae* Goeze.) were not above the economic threshold for chemical control, there was significant leaf-loss during seedling and pre-bolt stages. Later in the season, diamondback moth larvae (*Plutella xylstella* L.) were seen in significant numbers as well.

Several studies (Adkisson, 1957; Mattson, 1980; Funderburk et al., 1991) have shown that increased N-application can increase insect populations in crops due to a relatively high requirement by insects for N. The increased N availability caused an increase in pest herbivory and reproduction.

**Table 4. Yield Means Combined by Variety.**

| | Fairfield '92 | Moccasin '92 | Bozeman '92 | Fairfield '93 | Moccasin '93 | Bozeman '93 |
|---|---|---|---|---|---|---|
| Variety | kg ha$^{-1}$ | | | | | |
| Westar | 2224 | 802.1 | 1566 | 1310 | 1143 | 1974 |
| IMC-01 | 1631 | 477.2 | 748.4 | 1194 | 1277 | 1161 |
| IMC-129 | 2279 | 723.2 | 1053 | 1342 | 1192 | 1924 |

Another possible cause for a curvilinear response at Bozeman may have been a lesser degree of nitrate leaching and denitrification in relation to N uptake. This site received the higher rates of fertilization set for an irrigated site, but no irrigation was possible due to the unavailability of irrigation water. Although rainfall levels were higher than normal (ann. mean=34 cm) in both years (1.5x and 2x normal) , the plots received less water than would have been delivered through irrigation. Therefore the curvilinear response is what might be expected from a site which received a high rate of fertilization in

relation to the crop's ability to assimilate nutrients due to water limitations. The three varieties demonstrated a clear ranking in yield response (Table 4) which correlates approximately with the published varietal descriptions.

Nitrogen x variety interactions were not significant at any locations except at Bozeman in 1992 (Table 3). This response was also curvilinear in nature for all three varieties, at a significance level of 1%. The relative moisture deficit in relation to the rate of fertilization at this location may be responsible for this effect. IMC-01 has been recommended as an irrigation variety, and IMC-129 is often used for dryland conditions. The strong differences due to variety, treatment x variety interactions and the curvilinear yield response seen in this study concur with those assessments of the varieties' suitability for their respective moisture-management systems. This effect was not observed at Bozeman in 1993. This is probably attributable to high degree of residual variation (Table 3) which is probably from variations in pre-treatment fertility and other environmental factors within the location.

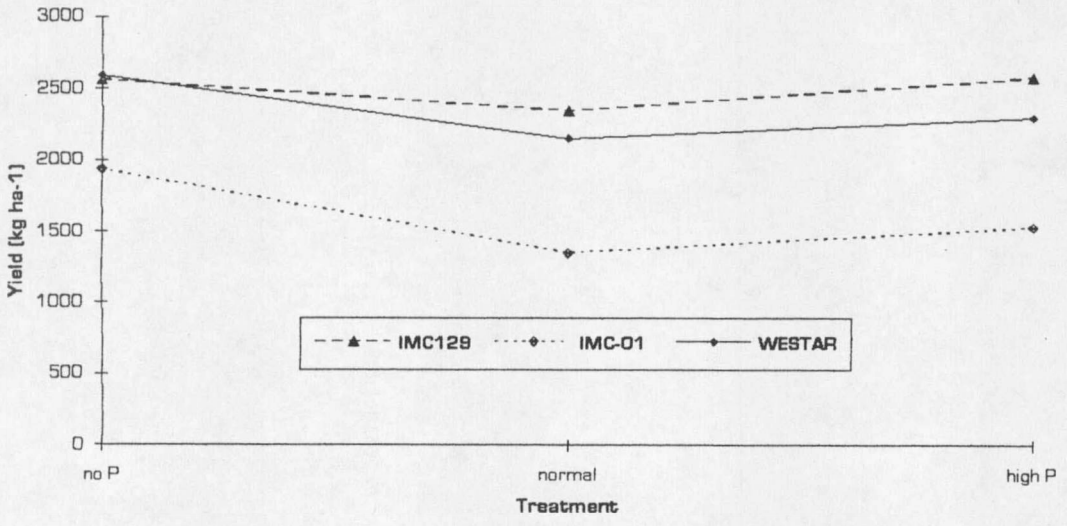
The expected ranking between IMC-01 and IMC-129 was reversed at Moccasin. This was probably due to a high degree of shattering observed in the earlier-maturing plots at this location. The highest yielding variety under the high N application was the IMC-129 in both seasons at Fairfield. Under high-moisture conditions this variety appeared to out-yield Westar. This is not fully consistent with varietal descriptions which recommend this variety for dryland use, and describe its yield as generally less than that of Westar. IMC-129 performed nearly as well as Westar at all locations in 1993, a year which could be characterized by having much higher than normal rainfall levels (approximately 2x normal at most locations). IMC-129 also out-performed Westar in 1992 at Fairfield,

another high-moisture location. From these data, it would seem that IMC-129 responds to high N levels nearly as well as Westar under high moisture, but further study is required for verification.

**Phosphorus Response**

There was only one significant linear response to phosphorus in the study. At Bozeman in 1992, a highly significant linear response ($p < 0.001$) was observed. Soil test results showed that existing soil P levels at Bozeman were higher than for most other locations. A possible explanation for this result is that the less extractable forms of P were present in the soil and available to the canola, but were not shown in the soil tests.

Figure 7. Yield Response to Phosphorus - Fairfield 1992




As many studies have shown (Soper and Racz, 1963; Grinsted et al., 1982), canola has a greater ability to extract the less labile fraction of soil P reserves than other crops. The less-available forms of phosphate may have been low in this location due to past

cropping treatments, thus the canola was utilizing the easily extractable forms of P for its growth requirements. Since the plant's requirement for P is high (Racz et al., 1965), there was a highly significant response to fertilizer P.

Statistical analysis showed a curvilinear response (P-quadratic in table 3) to P at Fairfield (Fig. 7) and Moccasin 1992, without a significant linear response. There was a depression in yield by the normal treatment in relation to the no P treatment, and this

Table 5. Soil Test Levels of N, P and S at Fairfield 1992.

| depth (cm) | $NO_3^-$ | $P_2O_5^-$ | $SO_4^=$ |
|---|---|---|---|
| | | ppm | |
| 0-15 | 5 | 21 | 8 |
| 15-30 | 2 | * | 9 |
| 30-61 | 2 | * | 9 |
| 61-91 | 8 | * | 13 |
| 91-122 | 2 | * | 13 |

* not tested

may be due to high levels of P in the spring (Table 5) which could have reduced yield due to seedling toxicity from fertilizer phosphate during germination, as canola is relatively sensitive to seedling damage (Nyborg, 1961). It appears that phosphate application may have reduced yield when soil P exists in high levels.

There were no significant interactions between variety and P treatments (Table 3: var. x P quadratic). Varieties did not react to treatments in a consistent and/or significant manner.

**Sulfur Response**

There was a highly significant ($p < 0.001$) linear response to sulfur at Moccasin in 1993 (Table 3). Soil test analysis in the spring of that year (Table 6) showed relatively low levels of available sulfate (5 ppm) in 0-15 cm of the soil profile, and may explain the significant response to S at this location. Another location (Fairfield 1992) had comparably low levels of S (<8 ppm) in the soil surface zone (0-15 cm) but significantly higher test levels of sulfate in the deeper zones. All locations showed higher sulfate amounts deeper in the profile than at surface levels (Table 6).

**Table 6. Soil Test Sulfate Levels**

| | Fairfield 1992 | Moccasin 1992 | Bozeman 1992 | Fairfield 1993 | Moccasin 1993 | Bozeman 1993 |
|---|---|---|---|---|---|---|
| **depth (cm)** | ppm | | | | | |
| **0-15** | 8 | 12 | 7 | 16 | 5 | 8 |
| **15-30** | 8 | 8 | 4 | 16 | 7 | 6 |
| **30-61** | 9 | 13 | 3 | 24 | 10 | 6 |
| **61-91** | 13 | 19 | 11 | 27 | 12 | 12 |
| **91-122** | 14 | 19 | 11 | 24 | 11 | 12 |

Fairly high sulfate levels at Fairfield in 1993 may explain the lack of significant response to S at that location (Tables 3 and 6). Mean yields were higher for the high-S treatment than for the no-S treatment (Fig. 11).

The experience of these two locations agrees with the observed phenomenon of sulfate movement up and down the soil profile with soil water (Castellano and Dick 1991). Although sulfate can be low in the surface layer in the spring, the lower levels can act as a sulfate reserve. As evapotranspiration moves soil water upward during the growing season, sulfates become available to the crop and in the fall, precipitation

moves it back down into the soil profile. Increased downward root growth may have occurred at this location in response to deeper sulfate reserves, but it was not measured in this study.

A significant variety x treatment interaction was observed at Fairfield in 1992. The two varieties: IMC-01 and IMC-129 responded differently to the S treatments at this location than did Westar (Fig. 8). IMC-01 and IMC-129 had a negative response while Westar had a positive response to S. This may indicate a varietal difference in the way these varieties utilize sulfate under the conditions specific to this location. A possible morphological explanation for intervarietal variation in sulfur uptake may be due to differing rooting depths and root densities at respective depths. Comparative data for rooting characteristics between the three varieties was not found, or has not been recorded.

A significant environmental factor which may have influenced sulfur uptake at this location was water availability. This site was flood-irrigated and received more water than the other two locations. This effect was not observed at Fairfield in 1993 however, and more evidence is needed to conclude that a varietal differential in sulfur assimilation exists between Westar and the two IMC varieties. Yields were lower however, for those 0two varieties than for Westar at Fairfield 1993 (Fig. 11) but were not statistically significant.

**Figure 8. Yield Response to Fertilizer Treatments - Fairfield 1992**

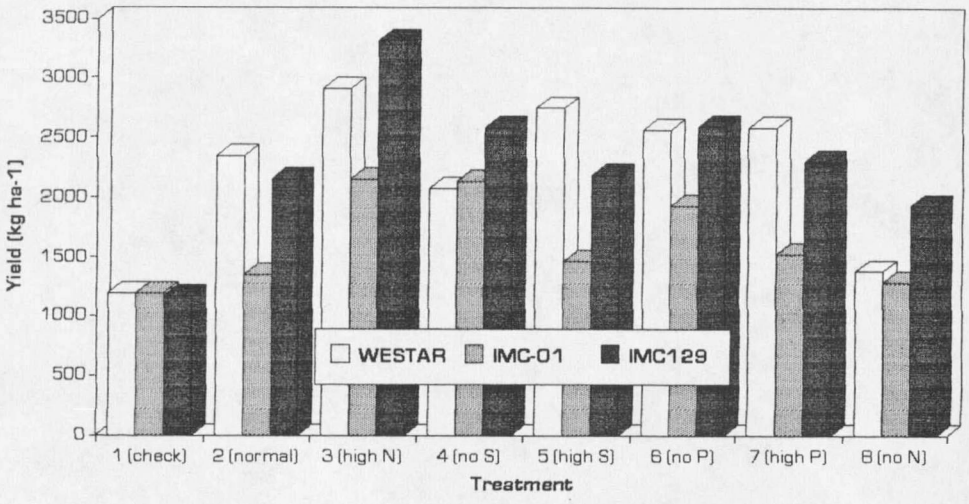



**Figure 9. Yield Response to Fertilizer Treatments - Moccasin 1992**

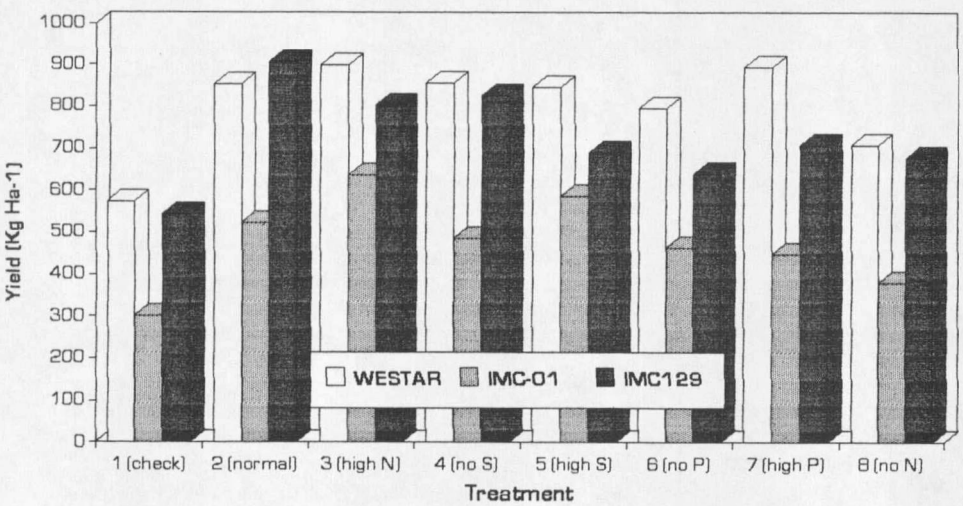


**Figure 10. Yield Response to Fertilizer Treatments - Bozeman 1992**

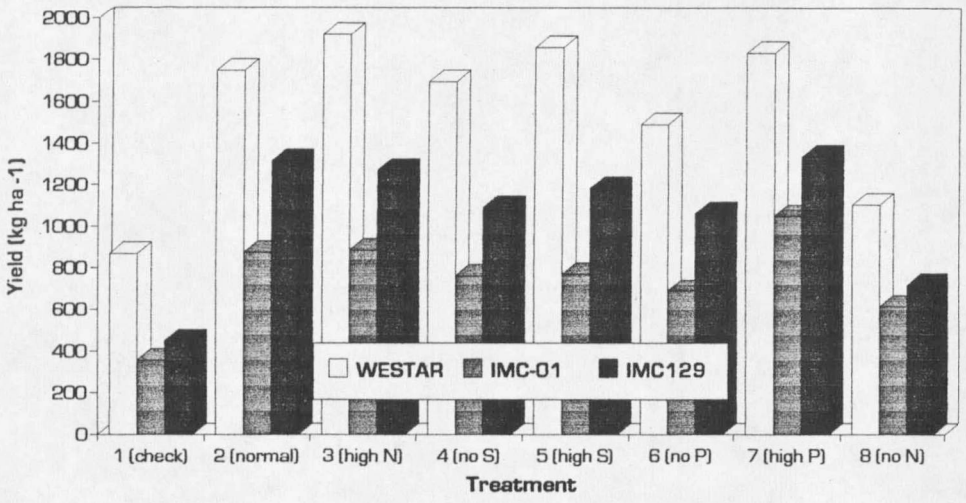



**Figure 11. Yield Response to Fertilizer Treatments - Fairfield 1993**

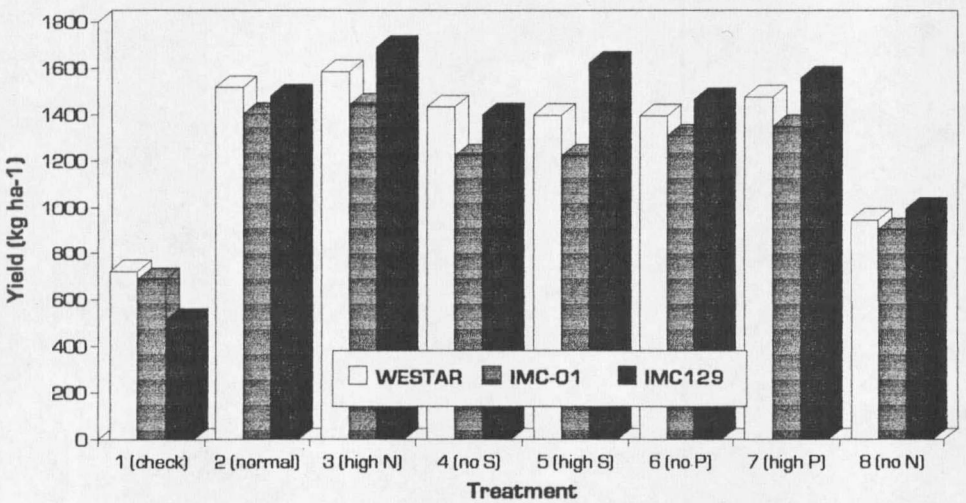


**Figure 12. Yield Response to Fertilizer Treatments - Moccasin 1993**

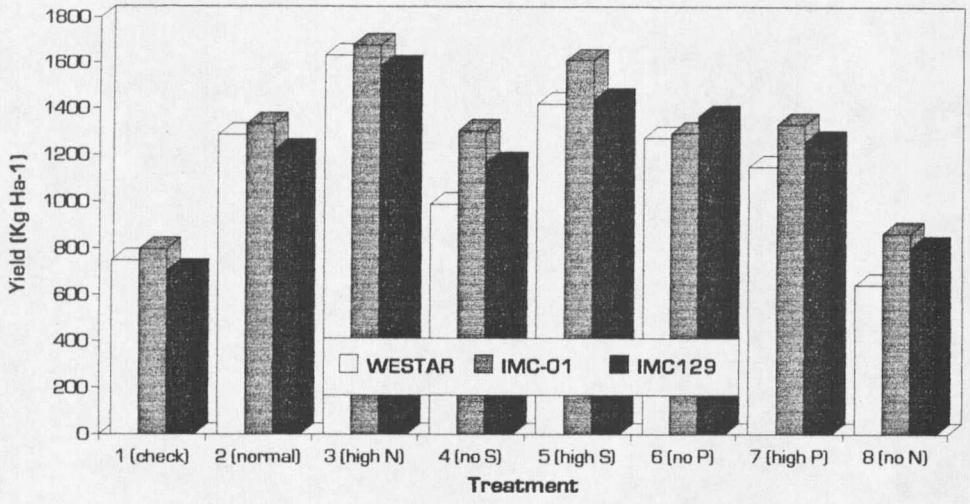
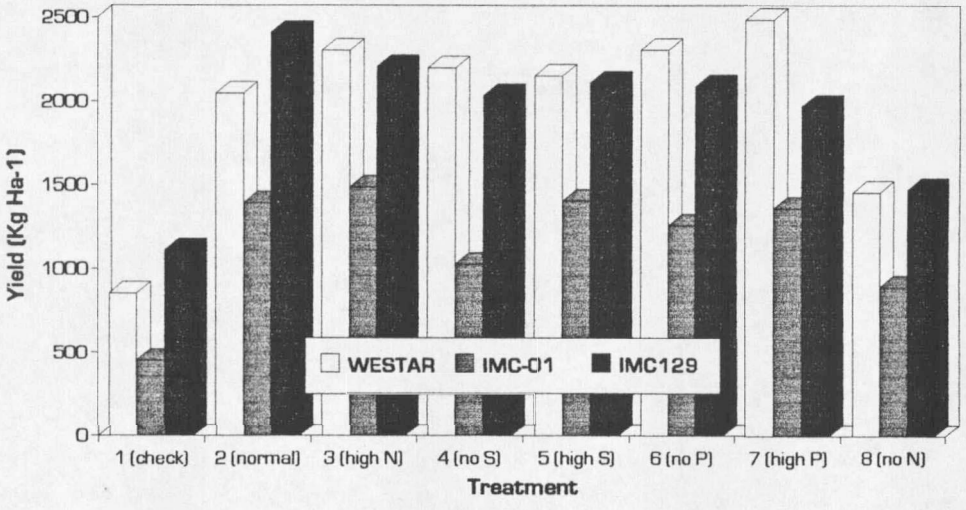



**Figure 13. Yield Response to Fertilizer Treatments - Bozeman 1993**



## Date of Flower Initiation

The influence of the fertilizer treatments on the date when flowers first appeared was highly significant at Bozeman in 1992, and at all locations in 1993 (Table 7). The lack of measurable response at Fairfield and Moccasin in 1992 may have each been due to different environmental factors at each location.

**Table 7. Analysis of Variance Mean Squares for Date of Flower Initiation.**

| | | Location/Year | | | | | |
|---|---|---|---|---|---|---|---|
| **Source** | df | Fairfield 1992 | Moccasin 1992 | Bozeman 1992 | Fairfield 1993 | Moccasin 1993 | Bozeman 1993 |
| Grand Mn. | - | 66.42 | 57.11 | 59.05 | 57.05 | 61.72 | 60.35 |
| Variety | **2** | 45.57 NS | 147.20** | 586.20*** | 122.70*** | 57.72** | 740.01* |
| Residual | **6** | 11.14 | 7.34 | 7.10 | 0.45 | 3.33 | 84.08 |
| Treatment | **7** | 7.55 NS | 1.64 NS | 24.62*** | 8.00*** | 23.67*** | 19.73** |
| Trt. x Var. | **14** | 7.20 NS | 1.51 NS | 3.31 NS | 1.90 NS | 1.72 NS | 6.24 NS |
| Residual | **6** | 4.49 | 1.80 | 2.00 | 1.44 | 2.82 | 6.34 |

NOTE: *, **, *** significant at 0.05, 0.01 and 0.001 respectively.

At Moccasin, a dry period in the spring may have lessened the effects of N on date of flower initiation by limiting N uptake by the plant.in that early stage of development. Since it is known that N can increase flower production (Berti and Mosca, 1987), this may explain the lack of variation due to treatment. The same effect may have occurred at Fairfield in the same year from other causes. Nitrogen may have been made less available to the plants during spring flood-irrigation. Denitrification, leaching and plant flooding may have occurred.

Varieties also demonstrated highly significant differences in the first appearance of flowers at all locations except Fairfield 1992 (Table 7). A clear ranking is apparent in

varieties at all locations (Figs. 14-19), which is consistent with published varietal descriptions. Westar was earliest, followed a few days later by IMC-129, and IMC-01 was the last to initiate flowering. At Fairfield 1992, the ranking was changed by an apparent delay in the flowering of Westar under the high-N and high-S treatments (Fig. 14). A significantly higher yield response to N and S was seen at this location than others, therefore the greater response to N by Westar alone may have canceled-out the significant variation due to variety (Table 7).

There were no treatment x variety interactions that were statistically significant at any of the six trials. This would indicate that all three varieties do not perform differently from each other under different fertilizer treatments. This is indicative of a stable genetic trait for date of flower initiation. Westar appeared to flower later than the other two varieties at Fairfield in 1992 under the high N and high S treatments. For any conclusions to be drawn about this apparent "location x variety x treatment" interaction, further studies with more precise measurement would be necessary under similar conditions.

Figure 14. Date of Flower Initiation - Fairfield 1992

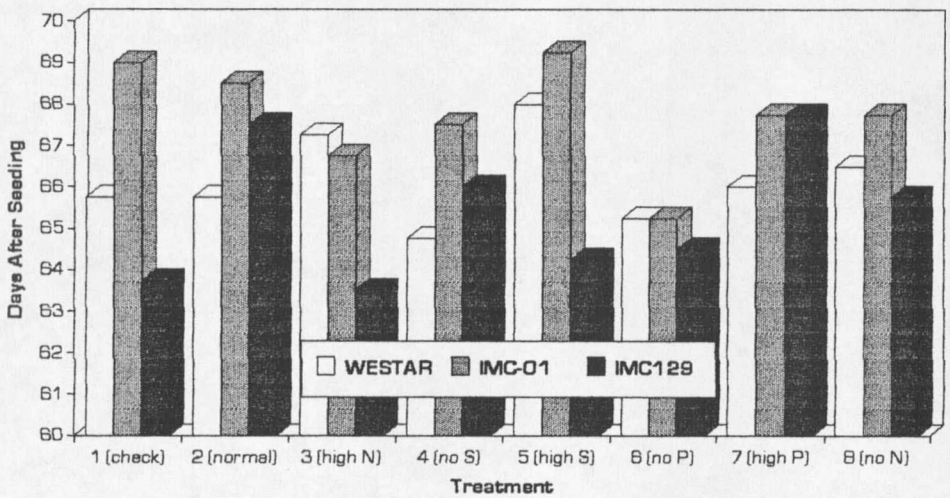


Figure 15. Date of Flower Initiation - Moccasin 1992

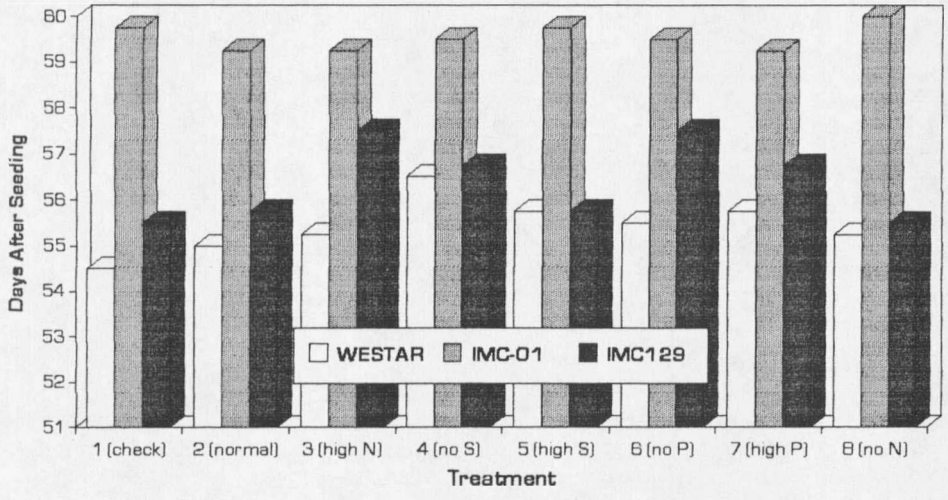



Figure 16. Date of Flower Initiation - Bozeman 1992

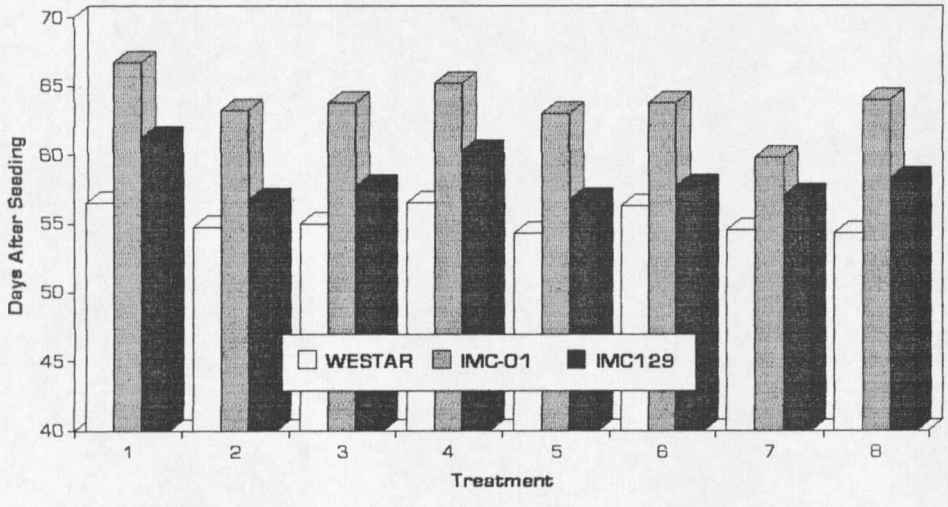


**Figure 17. Date of Flower Initiation - Fairfield 1993**

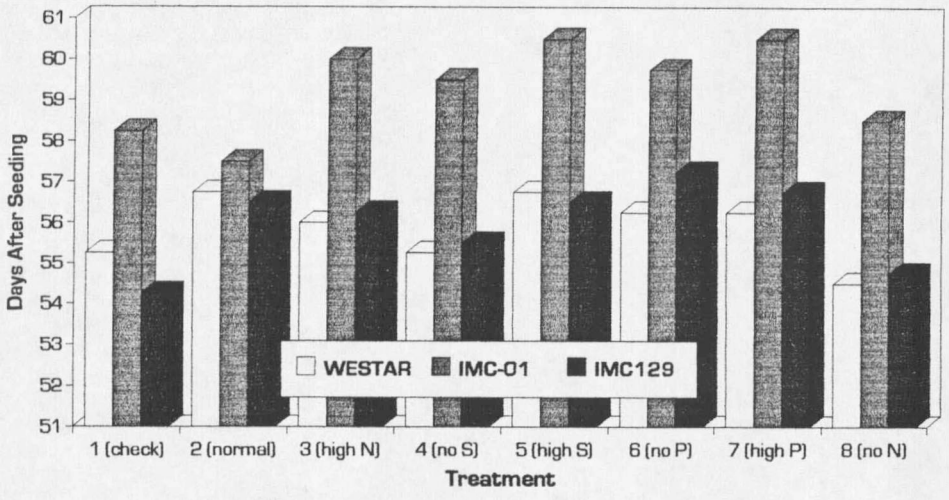



**Figure 18. Date of Flower Initiation - Moccasin 1993**

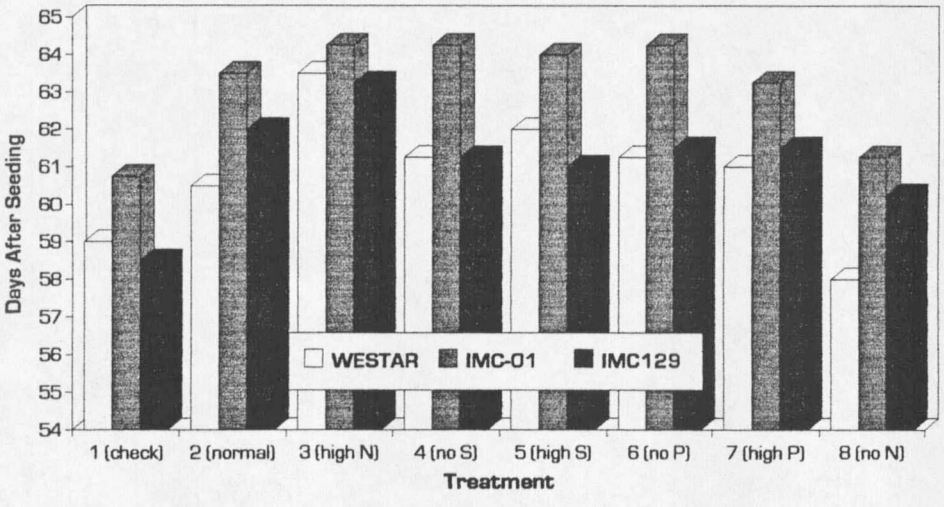
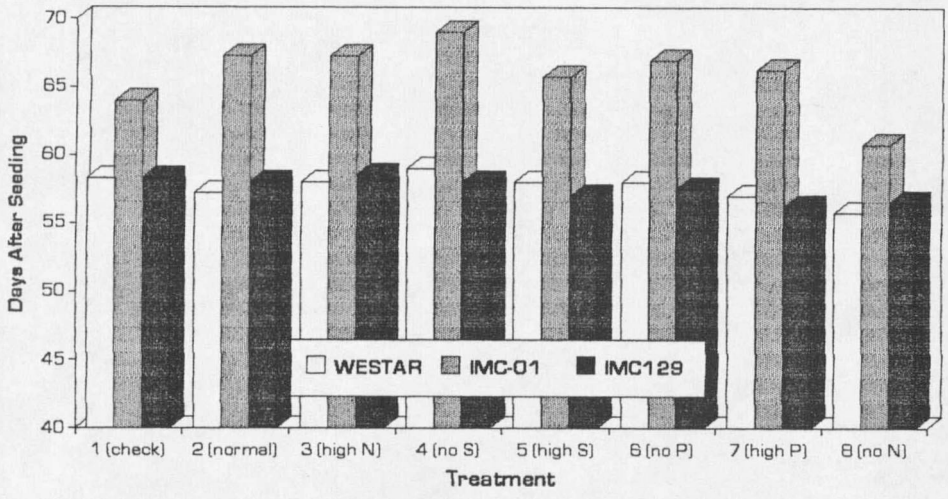


Figure 19. Date of Flower Initiation - Bozeman 1993




## Date of Color-Change (Swath Date).

Varietal differences in maturity were highly significant at all locations in 1992. The IMC-01 variety is described as having significantly different maturity performance (8 days later) as compared to Westar. IMC-129 is also described in relation to Westar as being 2 days later in maturity[1]. Observations corroborate these descriptions.

In 1993 there was also highly significant variation due to variety with the exception of the Fairfield site (Table 8). The most evident environmental factor at this location which was unique from other trials in this study, and may explain some site interaction was that of weed competition. Heavy rains and cool conditions after herbicide application may have been the cause of a heavy flush of wild oat (*Avenue fatua* L.). Competition effects such as shading may have caused differing phototropic effects specific to variety.

[1] Varietal descriptions issued from Intermountain Canola by personal communication Mar. 1994.

**Table 8. Analysis of Variance Mean Squares for Maturity (Days After Seeding)**

| Source | df | Location/Year | | | | | |
|---|---|---|---|---|---|---|---|
| | | Fairfield 1992 | Moccasin 1992 | Bozeman 1992 | Fairfield 1993 | Moccasin 1993 | Bozeman 1993 |
| Grand Mn. | - | 124.30 | 104.80 | 108.40 | 121.80 | 130.10 | 125.90 |
| Variety | 2 | 139.07 *** | 226.34 *** | 225.97 ** | 8.09 NS | 55.29 ** | 89.51 *** |
| Residual | 6 | 5.05 | 2.43 | 14.07 | 6.72 | 3.36 | 1.62 |
| Treatment | 7 | 4.21 NS | 5.76 NS | 7.57 *** | 1.13 NS | 11.327 *** | 5.62 * |
| Trt. x Var. | 14 | 3.08 NS | 5.80 NS | 1.48 NS | 3.70 | 1.26 NS | 1.30 NS |
| Residual | 6 | 2.41 | 5.47 | 1.25 | 3.92 | 1.24 | 2.42 |

NOTE: *, **, *** significant at 0.05, 0.01 and 0.001 respectively.

The relative effects of weed competition on specific canola varieties has not been studied to an extent which would sufficiently account for this effect. There was a significant delay in maturity within the no-sulfur treatment (no. 4) at Bozeman 1992 (Fig. 22) for all three varieties. The delayed maturity in treatments 1 and 8 (check and no-N) is most likely attributable to delayed growth (Scott et al., 1973), particularly in the seedling stage, and reduced flowering time (Thomas, 1985). Fairfield 1993 showed significant delay of maturity for IMC-01 and IMC-129 within the high S and high nitrogen applications. Bozeman and Moccasin (Figs. 21 & 22) were much earlier than Fairfield (Fig. 20) in 1992. An extended period of cool weather after planting delayed emergence and seedling development. Early planting has also been shown to delay maturity (Thomas 1985). The greatest variability in maturity was due to variety, followed by

treatment. The nitrogen treatments appeared to have a positive correlation with maturity in this study (Figs. 20 to 25).

**Figure 20. Maturity (Swath Date) - Fairfield 1992**

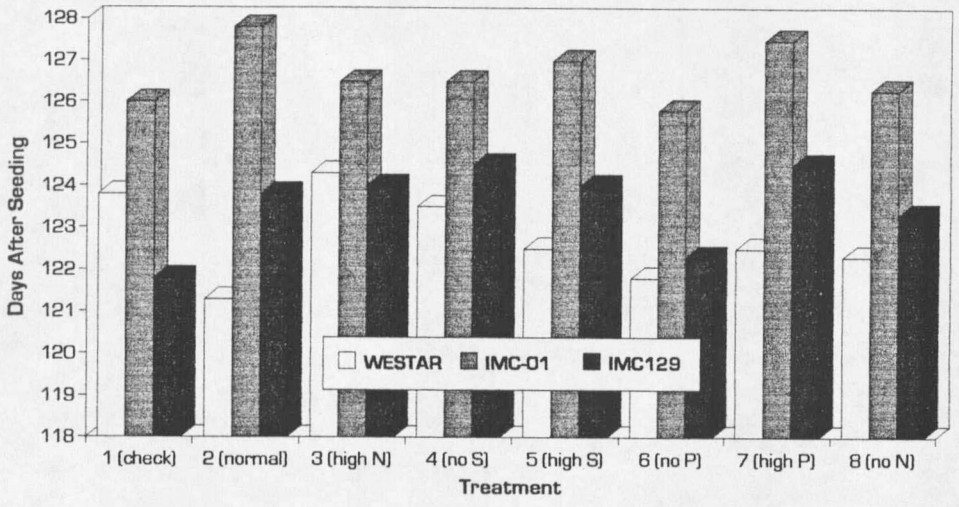



**Figure 21. Maturity (Swath Date) - Moccasin 1992**

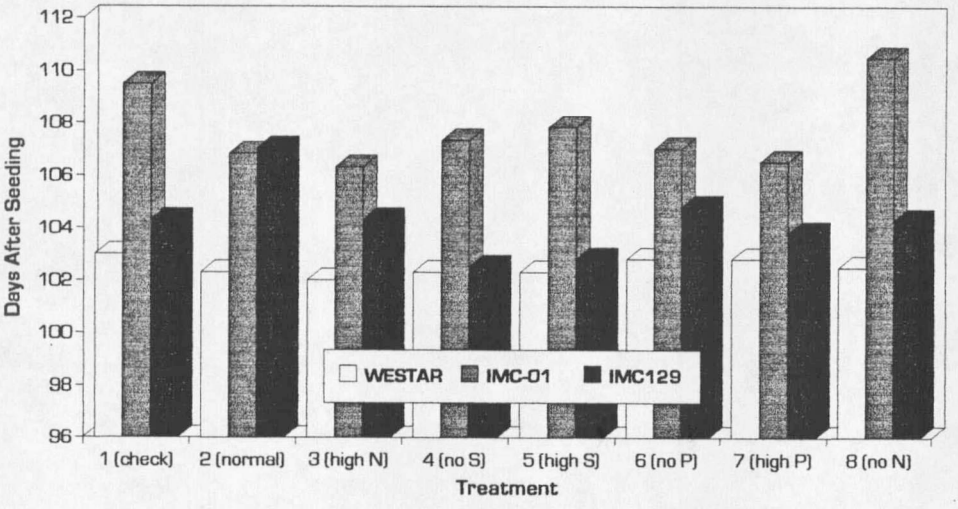


**Figure 22. Maturity (Swath Date) - Bozeman 1992**

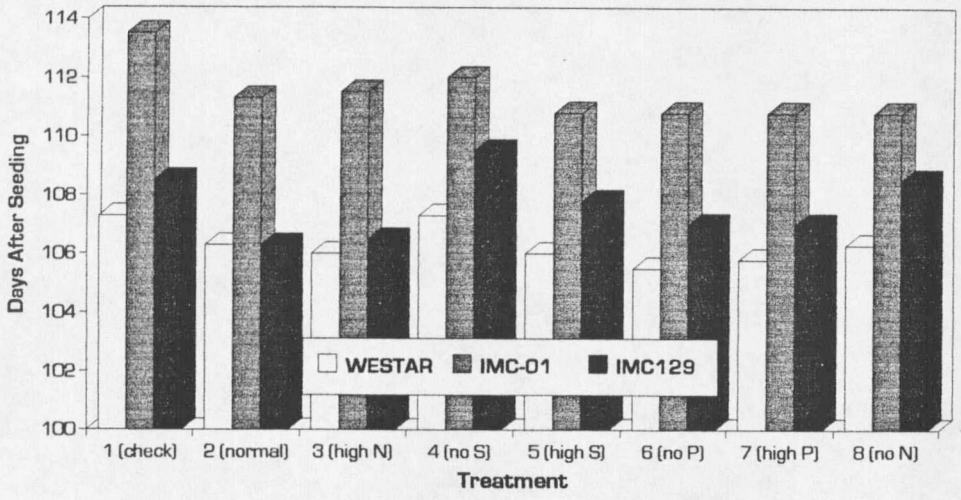



**Figure 23. Maturity (Swath Date) - Fairfield 1993**

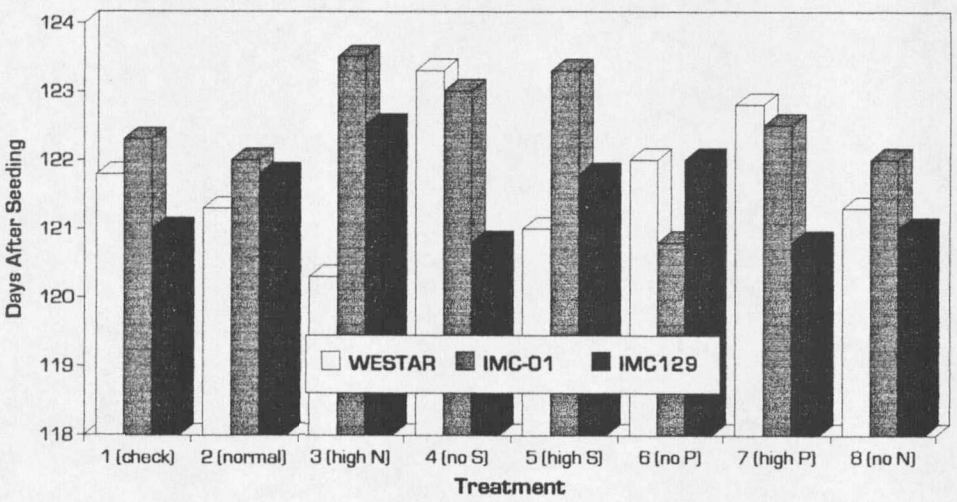


Figure 24. Maturity (Swath Date) - Moccasin 1993

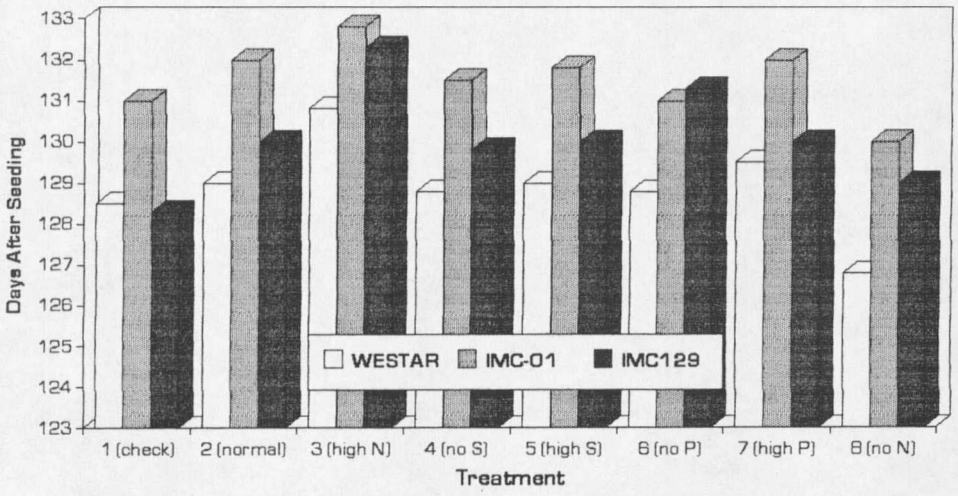
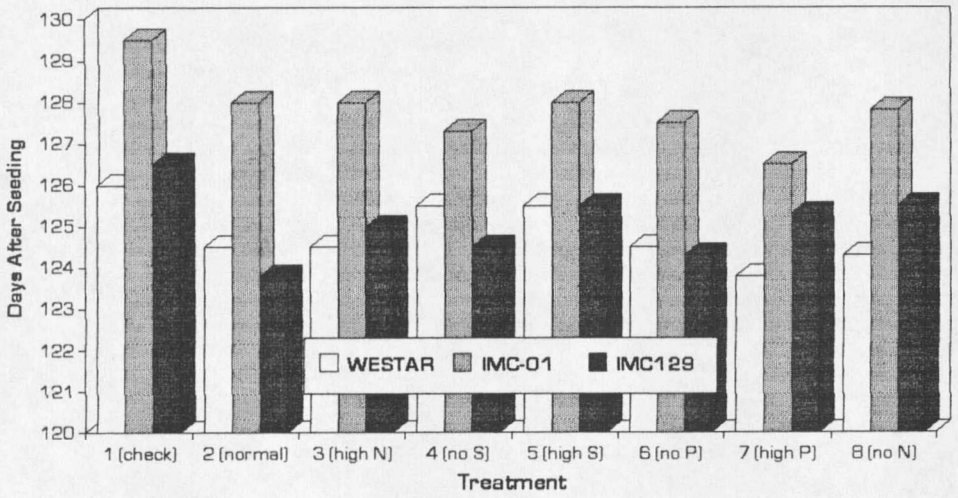



Figure 25. Maturity (Swath Date) - Bozeman 1993



## Seed Oil Content

Variety was a significant factor for differences in oil content at all locations except at Bozeman 1992 (Table 9). No consistent ranking among varieties was observed across all locations, and this inconsistency may be due to complex environment by variety interactions.

**Table 9. Analysis of Variance Mean Squares for Seed Oil Content (Percent)**

| | | Location/Year | | | | | |
|---|---|---|---|---|---|---|---|
| **Source** | df | Fairfield 1992 | Moccasin 1992 | Bozeman 1992 | Fairfield 1993 | Moccasin 1993 | Bozeman 1993 |
| Grand Mn. | - | 44.61 | 42.62 | 41.28 | 44.11 | 45.21 | 41.14 |
| Variety | 2 | 94.36*** | 83.49** | 40.65 NS | 30.73* | 9.05** | 14.10** |
| Residual | 6 | 2.44 | 5.44 | 52.04 | 3.98 | 0.86 | 1.60 |
| Treatment | 7 | 6.40** | 18.16*** | 42.03* | 4.35** | 3.19*** | 1.35 NS |
| Trt. x Var. | 14 | 0.78 NS | 11.11 NS | 15.26 NS | 1.01 NS | 0.79 NS | 0.72 NS |
| Residual | 6 | 1.75 | 1.06 | 15.69 | 1.14 | 0.51 | 0.97 |

NOTE: *, **, *** significant at 0.05, 0.01 and 0.001 respectively.

Fertilizer treatments were responsible for significant variation at all locations, except at Bozeman in 1993 (Fig. 31). The high N treatment caused a noticeable depression in oil content within the high-N treatment at most locations (Figs. 26 to 31) This agrees with previous research which shows an inverse relationship between oil content and nitrogen application (Bhatty, 1964; Allen and Morgan, 1972; Sheppard and Bates, 1980). Conversely, an elevation in oil content was evident in the check and no N applications.

Sulfur appeared to show little significant effect on oil content, with the exception of a slight depression in oil content with the high-S treatment in relation to the no-S

treatment at all three locations in 1993 (Figs. 29, 30 & 31). The same reduction in oil content was observed by Wetter in 1970 under S treatments. This effect was not seen at any locations in 1992. Phosphorus appeared to have no direct effect on oil content in this study. Treatment x variety interactions were not statistically significant at any locations in either year of the study.

Correlation between oil content and yield were not consistently negative or positive in this study. This was likely due to the assignment of nutrient treatments into 0, 1x and 2x levels. It is possible that experimental N rates which are varied more closely about optimum plant nutrition levels would show a better correlation. The low levels of N in some treatments may have reduced oil content by nutrient deprivation, thereby producing a positive correlation.

Figure 26. Seed Oil Content - Fairfield 1992

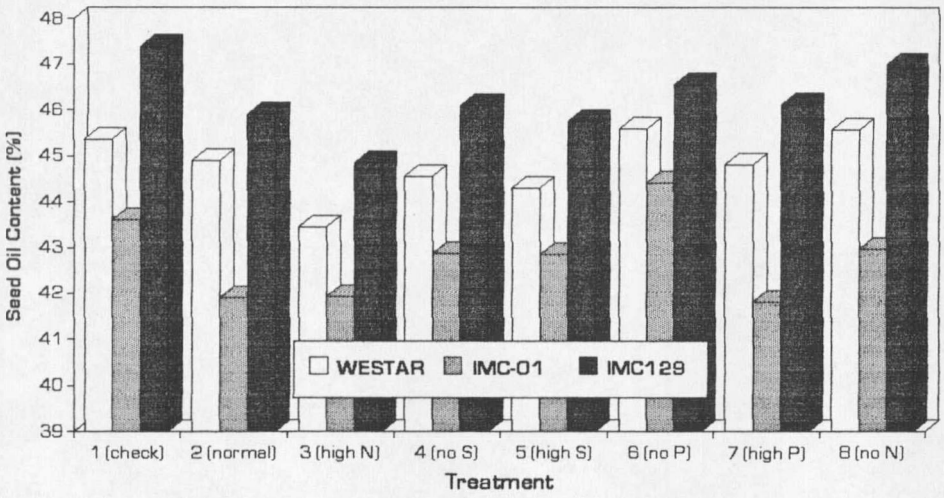


Figure 27. Seed Oil Content - Moccasin 1992

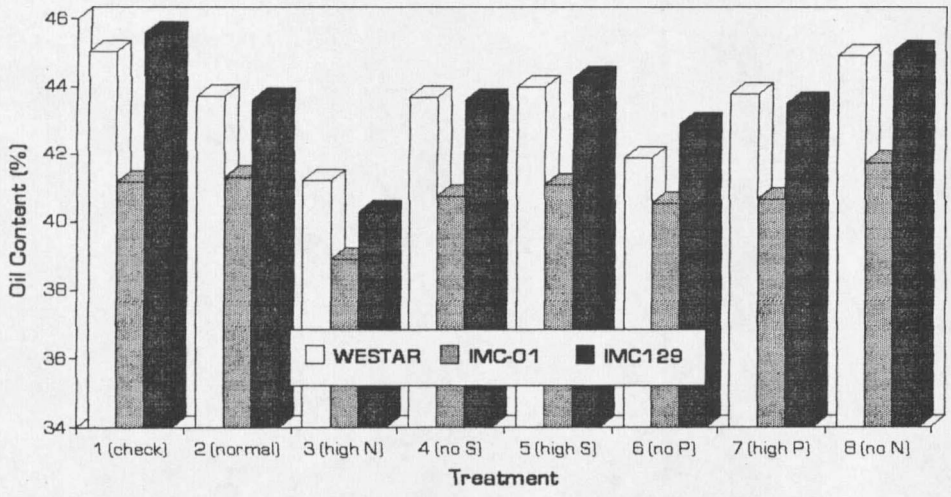



Figure 28. Seed Oil Content - Bozeman 1992

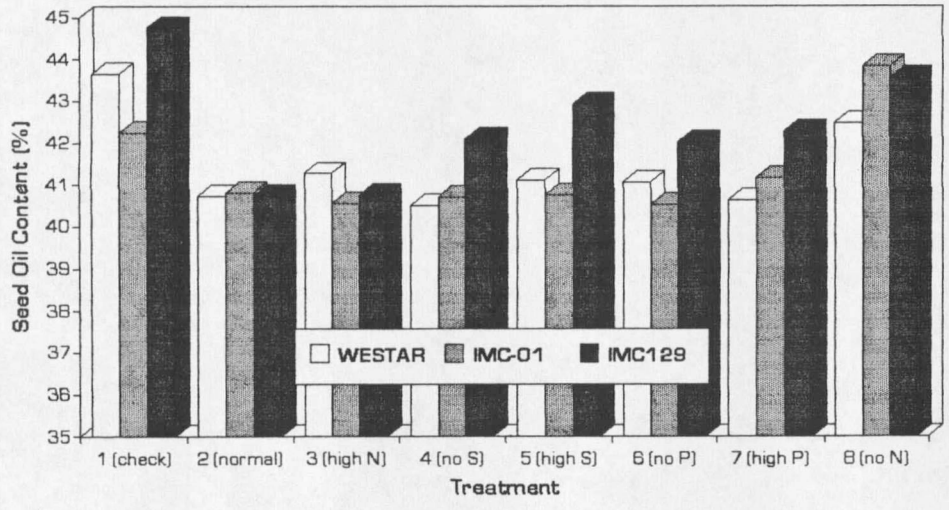


**Figure 29. Seed Oil Content - Fairfield 1993**

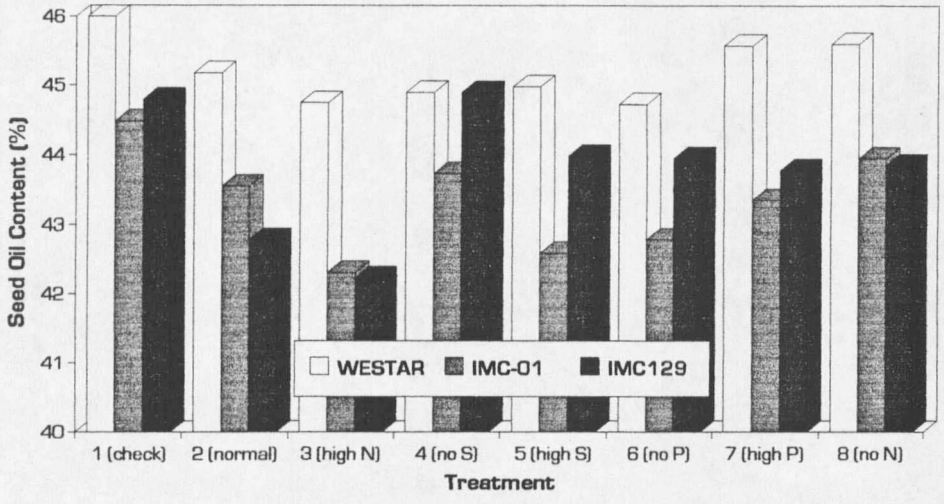



**Figure 30. Seed Oil Content - Moccasin 1993**

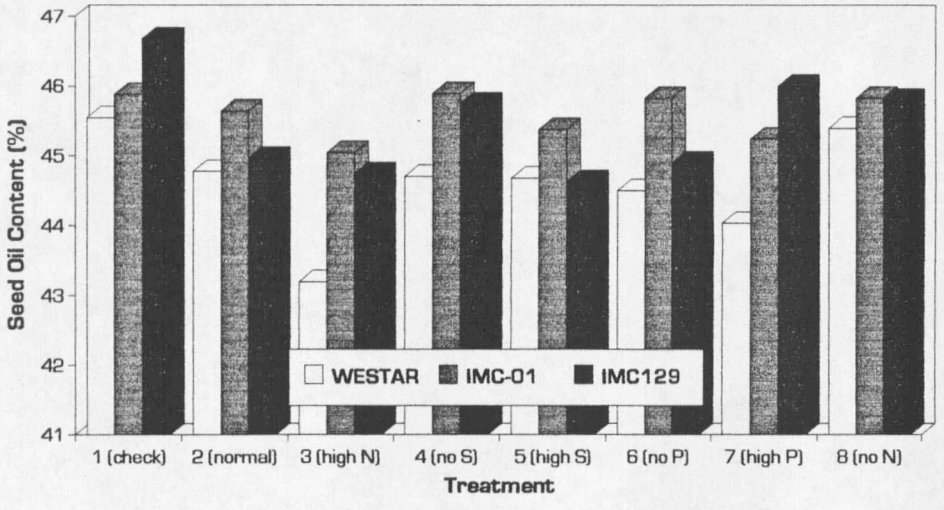
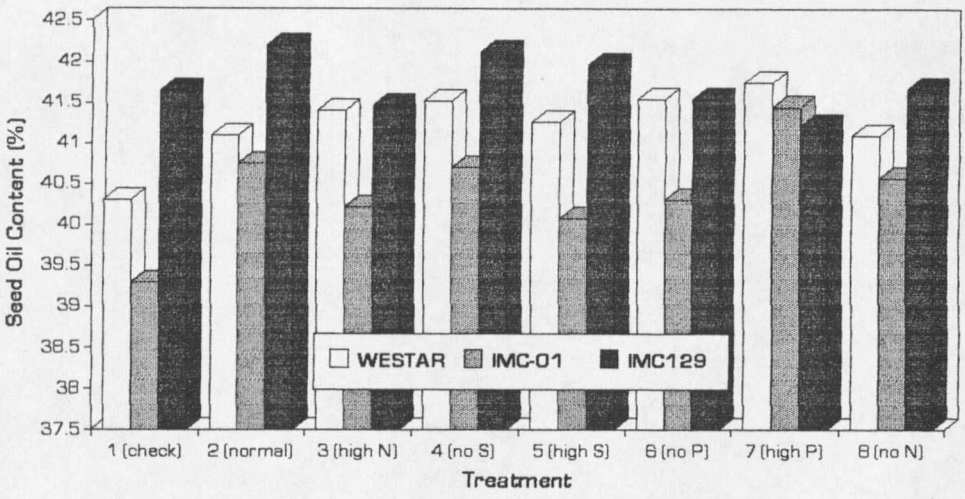


Figure 31. Seed Oil Content - Bozeman 1993




## Seed Density

This variable was expressed as weight in grams per 1000 seeds. Variation due to variety appeared to greatly outweigh that which was influenced by treatments (Table 10). Varietal differences were highly significant at Fairfield ($p<=0.0058$) and Bozeman ($p=0.0006$) in 1993, and not significant at Moccasin. There was a significant difference due to treatment at Moccasin ($p=0.026$). No data is available for 1992.

The differences due to variety are inherent in the respective genotypes. IMC-01 has a smaller seed than either Westar or IMC-01. Fertilizer treatments do not appear to have an effect on seed density with the exception of a small difference at Moccasin. A moderate amount of shattering occurred during harvest at this site, and larger, more mature seeds were lost. This probably accounts for the anomalous findings at that location.

**Table 10. Analysis of Variance Mean Squares for Seed Weight (grams per 1000 seeds)**

| Source | df | Location | | |
|---|---|---|---|---|
| | | Fairfield 1993 | Moccasin 1993 | Bozeman 1993 |
| Grand Mn. | - | 4.71 | 4.43 | 5.15 |
| Variety | 2 | 1.65** | .86 NS | 15.2*** |
| Residual | 6 | 0.12 | 0.26 | 0.46 |
| Treatment | 7 | .51 NS | .43* | 0.31 |
| Trt. x Var. | 14 | .14 NS | .24 NS | .31 NS |
| Residual | 6 | 0.12 | 0.17 | 0.32 |

Mean squares of each source of variation and the significant effect is shown at 0.05 (*), 0.01 (**), and 0.001 (***) levels.

## Lodging Scores

The erectness of the canola plants at maturity was not significantly affected by fertilizer treatment or variety at most of the trials in this study (Table 11). The only site that showed a significant difference due to treatment was Moccasin in 1993 ($p<0.05$).

**Table 11. Analysis of Variance Mean Squares for Lodging Scores**

| Source | df | Location/Year | | | | | |
|---|---|---|---|---|---|---|---|
| | | Fairfield 1992 | Moccasin 1992 | Bozeman 1992 | Fairfield 1993 | Moccasin 1993 | Bozeman 1993 |
| Grand Mn. | - | 2.06 | 1.08 | 3.10 | 1.88 | 1.05 | 3.42 |
| Variety | 2 | 0.94 NS | 0.45 NS | 0.45 NS | 2.09 NS | 16.14NS | 2.20 NS |
| Residual | 6 | 0.59 | 0.32 | 0.56 | 0.51 | 0.91 | 1.13 |
| Treatment | 7 | 0.40 NS | 0.95 NS | 0.76 NS | 0.74 NS | 1.36* | 0.60 NS |
| Trt. x Var. | 14 | 0.44 NS | 0.88 NS | 0.56 NS | 1.01 NS | 0.59 NS | 0.73 NS |
| Residual | 6 | 0.87 | 0.94 | 1.03 | 0.92 | 0.47 | 0.83 |

NOTE: *, **, *** significant at 0.05, 0.01 and 0.001 respectively.

Plant height was generally shorter at Moccasin, and lodging was much less evident. Lodging due to the high N treatment was therefore less obscured by factors of wind, rain and crop bending from adjacent plots.

# CHAPTER 5

## SUMMARY AND CONCLUSIONS

Perhaps the most significant factor in this study is the absence of any great anomalies in the fertility profiles of the Montana soils which were tested for canola production. Sulfur was not a severely limiting factor at any of the sites in this study which were selected based on the criterion of expected S deficiencies. This may indicate that S deficiency is not likely to be a severe management problem in Montana during the introductory phase of canola production.

It was found that two types of field methods to assess plant vigor were not a reliable estimate of final yield and crop condition. Neither the plant dry weight collection method nor the visual vigor score method yielded any useful correlation. This is probably due to the capacity of the canola plant to store carbohydrate reserved in the root and the effects of multiple environmental factors during the growing season.. A method which utilizes the entire plant may prove to be more useful for yield prediction and assessment of crop condition.

The effects of N application on most growth factors were fairly pronounced at most locations. Every location had highly significant yield responses to N, and this indicates that N is the major component in crop nutrient management.

Response to P and S was slight in this study at most sites and indicates near adequate reserves of these nutrients. Phosphorus has likely accumulated from past applications under cereal cropping. Canola has been known to tap this reserve with special adaptations which increase the uptake of P by enzymatic and acidic breakdown of the less labile phosphate fraction of the soil. This, and high soil test levels of P are the most acceptable explanations for a light response to phosphorus.

Sulfates are known to enter the rooting zone from below during the growing season, carried by upward water movement driven by evapotranspiration. This would probably explain the lack of strong response to S, together with the possibility of deep root penetration facilitated by genetic traits. In any event, deep soil sampling would seem to be an important prerequisite for growing canola, at least to establish whether deep sulfate and other nutrient reserves exist in a given field.

Maturity dates are significant in areas with limited growing seasons, and these are often the regions where canola is grown. The date when flowers first appeared in the canola plots and seed ripening dates were not greatly affected by fertilizer treatments, except where it was delayed by high N and high S treatments at some locations. This variability may have been due to complex environmental interactions which were not the focus of this study, but it is reasonable to expect that high rates of N and S may increase the risk of delayed maturity.

Seed oil content did not correlate with yield when analyzed by fertilizer treatments or variety, but when each location was analyzed separately, significant negative and positive correlations were found between nutrients and oil content. A larger

study would be required to identify which environmental factors are responsible for the correlations.

The seed density expressed as 1000-seed weight was unaffected by any treatment at any location in this study. Differences in seed size between the three varieties are highly significant ( largest to smallest: Westar, IMC-129, IMC-01), but are apparently well-fixed by genotype and showed no significant change due to any of the environmental factors in this experiment.

Lodging is an important practical consideration which often causes yield losses due to delayed maturity and mechanical harvesting losses. The ability of a crop to withstand bending due to wind and rain stresses is often a genetic trait. It is sometimes correlated to N induced growth and occasionally to K induced stem-strengthening. The nutrients applied in this study and the rates used did not appear to significantly affect standability. Lodging did not appear to be a problem with any of the varieties tested.

Fertilization appeared to minimize several pest problems. Moderate levels of insect pests at Bozeman in 1993 effected the greatest losses in unfertilized plots. Plots with the highest fertilization levels were less affected by insect pests. At Fairfield in the same year, weed competition was most severe in unfertilized plots, and barely noticeable with high N treatments. Delayed emergence at Moccasin in 1993 facilitated infection by seedling pathogens. Emergence was reduced by as much as 50% in unfertilized plots, but fertilized treatments showed little stand-count reduction.

Both years of this study were conducted under what proved to be high moisture conditions. Typical growing season precipitation in Montana is 30 - 50% lower than

what was experienced during this study. Drought or normal conditions could cause significantly different results than what was obtained in this study.

The hypothesis of this study was supported by several findings. The three areas tested did not show a strong response to P or to S, as is often shown in other areas. Reserves of these two nutrients may have accumulated under years of cereal grain cropping, and recommendations will have to be refined.. Although N response was strong, there may be a higher yield potential due to N at some locations in Montana than what was explored in this study. The warmer and drier climate in Montana as compared to western Canada is likely to require a refinement of inputs and existing management practices.

## LITERATURE CITED

Adkisson, P.L. 1957. The influence of fertilizer applications on populations of *Heliothis zea* (Boddie), and certain insect predators. *J. Econ. Entomol.* 51:757-759.

Allen, E.J., and D.G. Morgan. 1972. A quantitative analysis of the effects of nitrogen on the growth, development and yield of oilseed rape. *J. Agric. Sci. Camb.* 78: 315-324.

Bailey, L.D. and R.J. Soper. 1985. Potassium nutrition of rape, flax, sunflower, and safflower. *In: R.D. Munson, editor. Potassium in Agriculture. American Society of Agronomy, Madison WI.* pp. 765-798.

Bailey, L.D. and C.A. Grant. 1990b. Fertilizer placement studies on calcareous and non-calcareous chernozemic soils: Growth, P-uptake, oil content and yield of Canadian rape. *Comm. Soil Sci, Plant Anal. In. Press.*

Berti, A. and G. Mosca. 1987. Effetti della concimazione azotata sulla fruttificazione del colza invernale da olio (*Brassica napus* var. *olifera* D.C.). *Riv. di Agron.* 21:45-49.

Bhatty, R.S. 1964. Influence of nitrogen fertilization on the yield, protein and oil content of two varieties of rape. *Can. J. Plant Sci.* 44:215-217.

Booth, E.J., K.C. Walker, and D.W. Griffiths. 1991 A time-course study of the effect of sulphur on glucosinolates in oilseed rape *Brassica napus* from the vegetative stage to maturity. *J. Sci. Food Agric.* 56:479-493.

Castellano, S.D., and R.P. Dick. 1991. Cropping and sulfur fertilization influence on sulfur transformations in soil. *Soil Sci. Soc. Am. J.* 55:(1):114-121.

Diepenbrock, W., and G. Geisler. 1981. Einfluß der Stickstoffernährung auf den gehalt an chlorophyll und galaktolipiden alter und junger rapsblätter (*Brassica napus* L.) *Z. Pflanzenernaehr. Bodek.* 145: 2-9.

Edwards, A.C. 1991. Soil acidity and its interactions with phosphorus availability for a range of different crop types. *Dev. Plant Soil Sci.* 45:299-305.

Finlayson, A.J., C.M. Christ, and R.K. Downey. 1970. Changes in the nitrogenous components of rapeseed (*Brassica napus* L.) grown on a nitrogen and sulfur deficient soil. *Can. J. Plant Sci.* 50:705-709.

Funderburk J.E., I.D. Teare, and F.M. Rhoads. 1991. Population dynamics of soybean insect pests vs. soil nutrient levels. *Crop Sci.* 31:1629-1633.

Grant, C.A., and L.D. Bailey. 1993. Fertility management in canola production. *Can. J. Plant Sci. Rev. Can. Phytotech.* 73(3):651-670.

Grinsted, M. J., M.J. Hedley, R.E. White and P.H. Nye. 1982. Plant-induced changes in the rhizosphere of rape (*Brassica Napus* var. Emerald) seedlings. *New Phytol.* 91:19-29.

Hawkesford, M. J., J.C. Davidian and C. Grignon. 1993. Sulphate/proton cotransport in plasma-membrane vesicles isolated from roots of *Brassica napus* L. : increased transport in membranes isolated from sulphur-starved plants. *Planta.* 190(3):297-304.

Hedley, M.J., P.H. Nye, and R.E. White. 1983. Plant-induced changes in the rhizosphere of rape (*Brassica Napus* var. Emerald) seedlings. IV. The effect of rhizosphere phosphorus status on the pH phosphatase activity and depletion of soil phosphorus fractions in the rhizosphere and on the cation-anion balance in the plants. *New Phytol.* 95:99-82.

Henry, J.L., and K.B. MacDonald. 1978. The effects of soil and fertilizer nitrogen and moisture stress on yield, oil and protein content of rape. *Can. J. Soil Sci.* 58:303-310.

Josefsson, E.. 1971. Studies of the biochemical background to differences in glucosinolate content in relation to general chemical composition. *Physiol. Plant* 24:150-159.

Janzen, H.H., and J.R. Bettany. 1984. Sulfur nutrition of rapeseed: I. Influence of fertilizer nitrogen and sulfur rates. *Soil Sci. Soc. Am. J.* 48:100-107.

Lewis, C.E., and C.W. Knight. 1987. Yield response of rapeseed to row spacing, rates of seeding and N-fertilization in interior Alaska. *Can. J. Plant Sci.* 67:53-57.

Mailer, R.J. 1989. Effects of applied sulfur on glucosinolate and oil concentrations in the seeds of rape (*Brassica napus* L.) and turnip rape (*Brassica rapa* L. var. *silvestris* (Lam.) Briggs). *Aust. J. Agric. Res.* 40:617-24.

Marschner, H. 1986. Mineral Nutrition of Higher Plants. *Academic Press Inc. London.* 674 pp.

Mattson, W.J. Jr. 1980. Herbivory in relation to plant nitrogen content. *Ann. Rev. Ecol. Syst.* 11:119-161.

Nuttall, W.F., H. Ukrainetz, J.W.B. Stewart, and D.T. Spur. 1987. The effect of nitrogen, sulphur and boron on yield and quality of rapeseed (*Brassica napus* L. and *B. campestris* L.) *Can. J. Soil Sci.* 69:199-211.

Nuttall, W. F., W.K. Dawley, S.S. Mahli, and K.E. Bowren 1989. The effect of spring and fall application of N on yield and quality of barley (*Hordeum vulgare* L.) and rapeseed (*Brassica campestris* L.). *Can. J. Soil Sci.* 69:199-211.

Nuttall, W.F., A.P. Moulin, and L.J. Townley-Smith. 1992. Yield response of canola to nitrogen, phosphorus, precipitation and temperature. *Agron. J.* 84(5):765-768.

Nyborg, M. 1961. The effect of fertilizers on emergence of cereal grains, flax and rape. *Can J. Soil Sci.* 41:89-98.

Nyborg, M., C.F. Bentley, and P.B. Hoyt. 1974. Effect of sulphur deficiency on seed yield of turnip rape. *Sulphur Inst. J.* 10:14-15

Racz, G.J., M.D. Webber, R.J. Soper, and R.A. Hedlin. 1965. Phosphorus and nitrogen utilization by rape, flax and wheat. *Agron. J.* 57:335-337.

Rood, S.B., D.J. Major, J.M. Carefoot, and J.B. Bole. 1984. Seasonal distribution of nitrogen in oilseed rape. *Field Crops Research* 8:333-340.

Schjørring, J. K., and Paul Jensén. 1984a. Phosphorus nutrition of barley, buckwheat and rape seedlings. I. Influence of seed-borne P and external P levels on growth, P content and $^{32}P/^{31}P$-fractionation in shoots and roots. *Physiol. Plant* 61:577-583.

Schjørring, J. K., and Paul Jensén. 1984b. Phosphorus nutrition of barley, buckwheat and rape seedlings. II. Influx and efflux of phosphorus by intact roots of different status. *Physiol. Plant* 61:584-590.

Scott, R.K., E.A. Ogunremi, J.D. Ivins, and N.J. Mendham. 1973. The effect of fertilizers and harvest date on growth and yield of oilseed rape sown in autumn and spring. *J. Agric. Sci., Camb.* 81:287-293.

Sheppard, S.C., and T.E. Bates. 1980. Yield and composition of rape in response to nitrogen, phosphorus and potassium. *Can. J. Soil Sci.* 60:153-162.

Soper, R.J. 1971. Soil tests as a means of predicting response of rape to added N, P, and K. *Agron. J.* 63:564-566.

Soper, R.J., and G.J. Racz. 1963. Effect of fertilizer on various crops in Manitoba. *Papers presented at the 7th annual Manitoba Soil Sci. Meeting. University of Manitoba, Winnipeg, Manitoba.* pp. 93-100.

Taylor, A.J., C.J. Smith, and I.B. Wilson. 1991. Effect of irrigation and nitrogen fertilizer on yield, oil content, nitrogen accumulation and water use of canola (*Brassica napus* L.). *Fert. Res. Int. J. Fert. Use Technol.* 29(3):249-260.

Thomas, P. 1985. Canola Growers Manual. *Canola Council of Canada. Winnipeg Manitoba.*

Thompson, J.F., I.K. Smith, and J.T. Madison. 1986. Sulfur metabolism in plants. *In: Tabatabai, M.A. Editor, Sulfur in Agriculture. Agronomy Society of America. Madison WI.* pp. 57-121.

Wetter, L.R., H. Ukrainetz, and R.K. Downey. 1970. Effect of chemical fertilizers on the contents of oil, protein, and glucosinolates in *Brassicas* including rapeseed. *Int. Conf. on the Sci., Technology, and Marketing of Rapeseed and Rapeseed Products. St. Adele, Quebec, Canada. Canola Council of Canada. Winnipeg MB.*

Yusuf, R.I., and D.G. Bullock. 1993. Effect of several production factors on two varieties of rapeseed in the central United States. *J. Plant Nutr.* 16:1279-1288.

Zhao, F., P. Bilsborrow, E. Evans, and J.K. Syers. 1993. Sulfur turnover in the developing pods of single and double low varieties of oilseed rape (*Brassica napus* L.) *J. Sci. Food Agric.* 62:111-119.

# APPENDIX

## Table 12. Performance Means for Yield (kg ha$^{-1}$) by Location and Variety

| | | TREATMENTS | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location | var | 1 (check) | 2 (normal) | 3 (high N) | 4 (no S) | 5 (high S) | 6 (no P) | 7 (high P) | 8 (no N) |
| Fairfield | w | 1190.0 | 2349.0 | 2911.0 | 2075.0 | 2475.0 | 2563.0 | 2578.0 | 1382.0 |
| 1992 | 01 | 1192.0 | 1351.0 | 2155.0 | 2137.0 | 1461.0 | 1935.0 | 1528.0 | 1292.0 |
| | 129 | 1170.0 | 2153.0 | 3308.0 | 2585.0 | 2184.0 | 2593.0 | 2301.0 | 1936.0 |
| Moccasin | w | 573.0 | 851.8 | 897.8 | 855.3 | 845.8 | 794.5 | 893.0 | 705.5 |
| 1992 | 01 | 301.0 | 522.0 | 634.8 | 484.5 | 586.0 | 462.8 | 446.8 | 379.8 |
| | 129 | 541.8 | 906.3 | 802.0 | 824.8 | 689.3 | 638.8 | 705.8 | 677.0 |
| Bozeman | w | 868.5 | 1748.0 | 1923.0 | 1696.0 | 1860.0 | 1492.0 | 1835.0 | 1103.0 |
| 1992 | 01 | 355.7 | 872.7 | 883.7 | 759.2 | 767.2 | 688.0 | 1047.0 | 612.7 |
| | 129 | 447.0 | 1318.0 | 1272.0 | 1091.0 | 1184.0 | 1059.0 | 1338.0 | 716.7 |
| Fairfield | w | 720.2 | 1519.0 | 1587.0 | 1435.0 | 1399.0 | 1396.0 | 1479.0 | 948.0 |
| 1993 | 01 | 686.5 | 1404.0 | 1444.0 | 1225.0 | 1224.0 | 1311.0 | 1351.0 | 905.5 |
| | 129 | 511.0 | 1482.0 | 1691.0 | 1400.0 | 1624.0 | 1468.0 | 1560.0 | 994.0 |
| Moccasin | w | 748.0 | 1288.0 | 1634.0 | 988.3 | 1421.0 | 1274.0 | 1150.0 | 641.5 |
| 1993 | 01 | 795.5 | 1332.0 | 1681.0 | 1305.0 | 1613.0 | 1295.0 | 1334.0 | 862.3 |
| | 129 | 702.0 | 1219.0 | 1586.0 | 1165.0 | 1440.0 | 1367.0 | 1258.0 | 802.5 |
| Bozeman | w | 856.0 | 2048.0 | 2301.0 | 2199.0 | 2151.0 | 2305.0 | 2481.0 | 1453.0 |
| 1993 | 01 | 454.0 | 1395.0 | 1489.0 | 1029.0 | 1407.0 | 1261.0 | 1360.0 | 890.0 |
| | 129 | 1113.0 | 2408.0 | 2206.0 | 2033.0 | 2109.0 | 2087.0 | 1966.0 | 1470.0 |

## Table 13: Treatment Means for Yield (kg ha$^{-1}$)

| Treatment | Location/Year | | | | | |
|---|---|---|---|---|---|---|
| | Fairfield 1992 | Moccasin 1992 | Bozeman 1992 | Fairfield 1993 | Moccasin 1993 | Bozeman 1993 |
| 1 (check) | 1184 | 472 | 557 | 639 | 749 | 808 |
| 2 (normal) | 1951 | 760 | 1313 | 1468 | 1279 | 1950 |
| 3 (high N) | 2971 | 778 | 1360 | 1574 | 1634 | 1999 |
| 4 (no S) | 2266 | 722 | 1182 | 1353 | 1153 | 1754 |
| 5 (high S) | 2130 | 707 | 1271 | 1416 | 1491 | 1889 |
| 6 (no P) | 2363 | 632 | 1080 | 1392 | 1312 | 1884 |
| 7 (high P) | 2136 | 681 | 1407 | 1463 | 1247 | 1936 |
| 8 (no N) | 1537 | 587 | 811 | 949 | 769 | 1271 |
| CV (%) | 5.35 | 4.52 | 5.67 | 5.04 | 3.95 | 4.09 |
| LSD(0.05) | 309.3 | 85.19 | 179.80 | 182.50 | 134.40 | 194.90 |

CV, coefficient of variation is calculated from: (err.mn.sq./grand mean)
LSD, Least Significant Difference is calculated from: t (2MSE), where t=2.0.

**Table 14. Treatment Means for Maturity Date (Days)**

| Treatment | Location/Year | | | | | |
|---|---|---|---|---|---|---|
| | Fairfield 1992 | Moccasin 1992 | Bozeman 1992 | Fairfield 1993 | Moccasin 1993 | Bozeman 1993 |
| 1 (check) | 123.80 | 105.60 | 109.80 | 121.70 | 129.30 | 127.30 |
| 2 (normal) | 124.30 | 105.30 | 107.90 | 121.70 | 130.30 | 125.40 |
| 3 (high N) | 124.90 | 104.20 | 108.00 | 122.10 | 131.90 | 125.80 |
| 4 (no S) | 124.80 | 104.00 | 109.60 | 122.30 | 130.00 | 125.80 |
| 5 (high S) | 124.50 | 104.30 | 108.20 | 122.00 | 130.30 | 126.30 |
| 6 (no P) | 123.30 | 104.80 | 107.80 | 121.60 | 130.30 | 125.40 |
| 7 (high P) | 124.80 | 104.00 | 107.80 | 122.00 | 130.50 | 125.20 |
| 8 (no N) | 123.90 | 105.80 | 108.50 | 121.40 | 128.60 | 125.80 |
| CV (%) | **0.36** | **0.64** | **0.30** | **0.47** | **0.25** | **0.37** |
| LSD (0.05) | **1.26** | **1.91** | **0.91** | **1.61** | **0.90** | **1.27** |

CV, coefficient of variation is calculated from: (err.mn.sq./grand mean)
LSD, Least Significant Difference is calculated from: t (2MSE), where t=2.0.

## Table 15. Treatment Means for Seed Oil Content (Percent)

| Treatment | Location/Year | | | | | |
|---|---|---|---|---|---|---|
| | Fairfield 1992 | Moccasin 1992 | Bozeman 1992 | Fairfield 1993 | Moccasin 1993 | Bozeman 1993 |
| 1 (check) | 45.47 | 43.92 | 43.55 | 45.09 | 46.03 | 40.42 |
| 2 (normal) | 44.24 | 42.88 | 40.75 | 43.83 | 45.13 | 41.35 |
| 3 (high N) | 43.41 | 40.12 | 37.42 | 43.09 | 44.33 | 41.03 |
| 4 (no S) | 44.51 | 42.67 | 41.10 | 44.51 | 45.45 | 41.45 |
| 5 (high S) | 44.30 | 43.11 | 41.59 | 43.84 | 44.89 | 41.11 |
| 6 (no P) | 45.53 | 41.76 | 41.20 | 43.82 | 45.08 | 41.13 |
| 7 (high P) | 44.25 | 42.64 | 41.36 | 44.23 | 45.09 | 41.47 |
| 8 (no N) | 45.18 | 43.88 | 43.28 | 44.47 | 45.68 | 41.12 |
| CV (%) | 0.85 | 0.70 | 2.77 | 0.70 | 0.45 | 0.69 |
| LSD (0.05) | 1.08 | 0.84 | 3.23 | 0.87 | 0.58 | 0.80 |

CV, coefficient of variation is calculated from: (err.mn.sq./grand mean)
LSD, Least Significant Difference is calculated from: t (2MSE), where t=2.0.

# Table 16. Plot Layout

Fairfield 1992

| PLOT | BLOCK | TREATMENT | NPKS | VARIETY |
|---|---|---|---|---|
| 101 | 1 | 1 | 0-0-0-0 | WESTAR |
| 102 | 1 | 2 | 100-30-0-20 | WESTAR |
| 103 | 1 | 3 | 150-30-0-20 | WESTAR |
| 104 | 1 | 4 | 100-30-0-0 | WESTAR |
| 105 | 1 | 1 | 0-0-0-0 | IMC-01 |
| 106 | 1 | 2 | 100-30-0-20 | IMC-01 |
| 107 | 1 | 3 | 150-30-0-20 | IMC-01 |
| 108 | 1 | 4 | 100-30-0-0 | IMC-01 |
| 109 | 1 | 1 | 0-0-0-0 | IMC129 |
| 110 | 1 | 2 | 100-30-0-20 | IMC129 |
| 111 | 1 | 3 | 150-30-0-20 | IMC129 |
| 112 | 1 | 4 | 100-30-0-0 | IMC129 |
| 113 | 1 | 5 | 100-30-0-40 | WESTAR |
| 114 | 1 | 6 | 100-0-0-20 | WESTAR |
| 115 | 1 | 7 | 100-60-0-20 | WESTAR |
| 116 | 1 | 8 | 17-30-0-20 | WESTAR |
| 117 | 1 | 5 | 100-30-0-40 | IMC-01 |
| 118 | 1 | 6 | 100-0-0-20 | IMC-01 |
| 119 | 1 | 7 | 100-60-0-20 | IMC-01 |
| 120 | 1 | 8 | 17-30-0-20 | IMC-01 |
| 121 | 1 | 5 | 100-30-0-40 | IMC129 |
| 122 | 1 | 6 | 100-0-0-20 | IMC129 |
| 123 | 1 | 7 | 100-60-0-20 | IMC129 |
| 124 | 1 | 8 | 17-30-0-20 | IMC129 |
| 201 | 2 | 6 | 100-0-0-20 | IMC-01 |
| 202 | 2 | 1 | 0-0-0-0 | IMC-01 |
| 203 | 2 | 8 | 17-30-0-20 | IMC-01 |
| 204 | 2 | 3 | 150-30-0-20 | IMC-01 |
| 205 | 2 | 6 | 100-0-0-20 | IMC129 |
| 206 | 2 | 1 | 0-0-0-0 | IMC129 |
| 207 | 2 | 8 | 17-30-0-20 | IMC129 |
| 208 | 2 | 3 | 150-30-0-20 | IMC129 |
| 209 | 2 | 4 | 100-30-0-0 | WESTAR |
| 210 | 2 | 1 | 0-0-0-0 | WESTAR |
| 211 | 2 | 6 | 100-0-0-20 | WESTAR |
| 212 | 2 | 3 | 150-30-0-20 | WESTAR |
| 213 | 2 | 5 | 100-30-0-40 | IMC-01 |
| 214 | 2 | 2 | 100-30-0-20 | IMC-01 |
| 215 | 2 | 7 | 100-60-0-20 | IMC-01 |
| 216 | 2 | 4 | 100-30-0-0 | IMC-01 |
| 217 | 2 | 5 | 100-30-0-40 | IMC129 |
| 218 | 2 | 7 | 100-60-0-20 | IMC129 |
| 219 | 2 | 2 | 100-30-0-20 | IMC129 |
| 220 | 2 | 4 | 100-30-0-0 | IMC129 |
| 221 | 2 | 8 | 17-30-0-20 | WESTAR |
| 222 | 2 | 2 | 100-30-0-20 | WESTAR |
| 223 | 2 | 7 | 100-60-0-20 | WESTAR |
| 224 | 2 | 5 | 100-30-0-40 | WESTAR |
| 301 | 3 | 5 | 100-30-0-40 | IMC129 |
| 302 | 3 | 2 | 100-30-0-20 | IMC129 |
| 303 | 3 | 6 | 100-0-0-20 | IMC129 |
| 304 | 3 | 8 | 17-30-0-20 | IMC129 |
| 305 | 3 | 6 | 100-0-0-20 | WESTAR |
| 306 | 3 | 4 | 100-30-0-0 | WESTAR |
| 307 | 3 | 1 | 0-0-0-0 | WESTAR |
| 308 | 3 | 8 | 17-30-0-20 | WESTAR |
| 309 | 3 | 2 | 100-30-0-20 | IMC-01 |
| 310 | 3 | 5 | 100-30-0-40 | IMC-01 |
| 311 | 3 | 1 | 0-0-0-0 | IMC-01 |
| 312 | 3 | 7 | 100-60-0-20 | IMC-01 |
| 313 | 3 | 4 | 100-30-0-0 | IMC129 |
| 314 | 3 | 7 | 100-60-0-20 | IMC129 |
| 315 | 3 | 1 | 0-0-0-0 | IMC129 |
| 316 | 3 | 3 | 150-30-0-20 | IMC129 |
| 317 | 3 | 5 | 100-30-0-40 | WESTAR |
| 318 | 3 | 2 | 100-30-0-20 | WESTAR |
| 319 | 3 | 7 | 100-60-0-20 | WESTAR |
| 320 | 3 | 3 | 150-30-0-20 | WESTAR |
| 321 | 3 | 4 | 100-30-0-0 | IMC-01 |
| 322 | 3 | 8 | 17-30-0-20 | IMC-01 |
| 323 | 3 | 3 | 150-30-0-20 | IMC-01 |
| 324 | 3 | 6 | 100-0-0-20 | IMC-01 |
| 401 | 4 | 7 | 100-60-0-20 | WESTAR |
| 402 | 4 | 3 | 150-30-0-20 | WESTAR |
| 403 | 4 | 8 | 17-30-0-20 | WESTAR |
| 404 | 4 | 4 | 100-30-0-0 | WESTAR |
| 405 | 4 | 4 | 100-30-0-0 | IMC-01 |
| 406 | 4 | 7 | 100-60-0-20 | IMC-01 |
| 407 | 4 | 3 | 150-30-0-20 | IMC-01 |
| 408 | 4 | 8 | 17-30-0-20 | IMC-01 |
| 409 | 4 | 1 | 0-0-0-0 | IMC129 |
| 410 | 4 | 4 | 100-30-0-0 | IMC129 |
| 411 | 4 | 8 | 17-30-0-20 | IMC129 |
| 412 | 4 | 2 | 100-30-0-20 | IMC129 |
| 413 | 4 | 2 | 100-30-0-20 | WESTAR |
| 414 | 4 | 5 | 100-30-0-40 | WESTAR |
| 415 | 4 | 6 | 100-0-0-20 | WESTAR |
| 416 | 4 | 1 | 0-0-0-0 | WESTAR |
| 417 | 4 | 2 | 100-30-0-20 | IMC-01 |
| 418 | 4 | 6 | 100-0-0-20 | IMC-01 |
| 419 | 4 | 1 | 0-0-0-0 | IMC-01 |
| 420 | 4 | 5 | 100-30-0-40 | IMC-01 |
| 421 | 4 | 7 | 100-60-0-20 | IMC129 |
| 422 | 4 | 6 | 100-0-0-20 | IMC129 |
| 423 | 4 | 3 | 150-30-0-20 | IMC129 |
| 424 | 4 | 5 | 100-30-0-40 | IMC129 |

## Table 16 ----continued.

Moccasin 1992

| PLOT | BLOCK | TREATMENT | NPKS | VARIETY |
|---|---|---|---|---|
| 101 | 1 | 1 | 0-0-0-0 | WESTAR |
| 102 | 1 | 2 | 50-20-0-20 | WESTAR |
| 103 | 1 | 3 | 100-20-0-20 | WESTAR |
| 104 | 1 | 4 | 50-20-0-0 | WESTAR |
| 105 | 1 | 5 | 50-20-0-40 | WESTAR |
| 106 | 1 | 6 | 50-0-0-20 | WESTAR |
| 107 | 1 | 7 | 50-40-0-20 | WESTAR |
| 108 | 1 | 8 | 17-20-0-20 | WESTAR |
| 109 | 1 | 1 | 0-0-0-0 | IMC-01 |
| 110 | 1 | 2 | 50-20-0-20 | IMC-01 |
| 111 | 1 | 3 | 100-20-0-20 | IMC-01 |
| 112 | 1 | 4 | 50-20-0-0 | IMC-01 |
| 113 | 1 | 5 | 50-20-0-40 | IMC-01 |
| 114 | 1 | 6 | 50-0-0-20 | IMC-01 |
| 115 | 1 | 7 | 50-40-0-20 | IMC-01 |
| 116 | 1 | 8 | 17-20-0-20 | IMC-01 |
| 117 | 1 | 1 | 0-0-0-0 | IMC129 |
| 118 | 1 | 2 | 50-20-0-20 | IMC129 |
| 119 | 1 | 3 | 100-20-0-20 | IMC129 |
| 120 | 1 | 4 | 50-20-0-0 | IMC129 |
| 121 | 1 | 5 | 50-20-0-40 | IMC129 |
| 122 | 1 | 6 | 50-0-0-20 | IMC129 |
| 123 | 1 | 7 | 50-40-0-20 | IMC129 |
| 124 | 1 | 8 | 17-20-0-20 | IMC129 |
| 201 | 2 | 3 | 100-20-0-20 | IMC-01 |
| 202 | 2 | 7 | 50-40-0-20 | IMC-01 |
| 203 | 2 | 1 | 0-0-0-0 | IMC-01 |
| 204 | 2 | 8 | 17-20-0-20 | IMC-01 |
| 205 | 2 | 2 | 50-20-0-20 | IMC-01 |
| 206 | 2 | 5 | 50-20-0-40 | IMC-01 |
| 207 | 2 | 4 | 50-20-0-0 | IMC-01 |
| 208 | 2 | 6 | 50-0-0-20 | IMC-01 |
| 209 | 2 | 3 | 100-20-0-20 | IMC129 |
| 210 | 2 | 7 | 50-40-0-20 | IMC129 |
| 211 | 2 | 1 | 0-0-0-0 | IMC129 |
| 212 | 2 | 8 | 17-20-0-20 | IMC129 |
| 213 | 2 | 2 | 50-20-0-20 | IMC129 |
| 214 | 2 | 5 | 50-20-0-40 | IMC129 |
| 215 | 2 | 4 | 50-20-0-0 | IMC129 |
| 216 | 2 | 6 | 50-0-0-20 | IMC129 |
| 217 | 2 | 3 | 100-20-0-20 | WESTAR |
| 218 | 2 | 7 | 50-40-0-20 | WESTAR |
| 219 | 2 | 1 | 0-0-0-0 | WESTAR |
| 220 | 2 | 8 | 17-20-0-20 | WESTAR |
| 221 | 2 | 2 | 50-20-0-20 | WESTAR |
| 222 | 2 | 5 | 50-20-0-40 | WESTAR |
| 223 | 2 | 4 | 50-20-0-0 | WESTAR |
| 224 | 2 | 6 | 50-0-0-20 | WESTAR |
| 301 | 3 | 8 | 17-20-0-20 | IMC129 |
| 302 | 3 | 6 | 50-0-0-20 | IMC129 |
| 303 | 3 | 4 | 50-20-0-0 | IMC129 |
| 304 | 3 | 5 | 50-20-0-4 | IMC129 |
| 305 | 3 | 1 | 0-0-0-0 | IMC129 |
| 306 | 3 | 3 | 100-20-0-20 | IMC129 |
| 307 | 3 | 7 | 50-40-0-20 | IMC129 |
| 308 | 3 | 2 | 50-20-0-20 | IMC129 |
| 309 | 3 | 8 | 17-20-0-20 | WESTAR |
| 310 | 3 | 6 | 50-0-0-20 | WESTAR |
| 311 | 3 | 4 | 50-20-0-0 | WESTAR |
| 312 | 3 | 5 | 50-20-0-40 | WESTAR |
| 313 | 3 | 1 | 0-0-0-0 | WESTAR |
| 314 | 3 | 3 | 100-20-0-20 | WESTAR |
| 315 | 3 | 7 | 50-40-0-20 | WESTAR |
| 316 | 3 | 2 | 50-20-0-20 | WESTAR |
| 317 | 3 | 8 | 17-20-0-20 | IMC-01 |
| 318 | 3 | 6 | 50-0-0-20 | IMC-01 |
| 319 | 3 | 4 | 50-20-0-0 | IMC-01 |
| 320 | 3 | 5 | 50-20-0-40 | IMC-01 |
| 321 | 3 | 1 | 0-0-0-0 | IMC-01 |
| 322 | 3 | 3 | 100-20-0-20 | IMC-01 |
| 323 | 3 | 7 | 50-40-0-20 | IMC-01 |
| 324 | 3 | 2 | 50-20-0-20 | IMC-01 |
| 401 | 4 | 6 | 50-0-0-20 | IMC129 |
| 402 | 4 | 3 | 100-20-0-20 | IMC129 |
| 403 | 4 | 7 | 50-40-0-20 | IMC129 |
| 404 | 4 | 2 | 50-20-0-20 | IMC129 |
| 405 | 4 | 4 | 50-20-0-0 | IMC129 |
| 406 | 4 | 8 | 17-20-0-20 | IMC129 |
| 407 | 4 | 5 | 50-20-0-40 | IMC129 |
| 408 | 4 | 1 | 0-0-0-0 | IMC129 |
| 409 | 4 | 6 | 50-0-0-20 | IMC-01 |
| 410 | 4 | 3 | 100-20-0-20 | IMC-01 |
| 411 | 4 | 7 | 50-40-0-20 | IMC-01 |
| 412 | 4 | 2 | 50-20-0-20 | IMC-01 |
| 413 | 4 | 4 | 50-20-0-0 | IMC-01 |
| 414 | 4 | 8 | 17-20-0-20 | IMC-01 |
| 415 | 4 | 5 | 50-20-0-40 | IMC-01 |
| 416 | 4 | 1 | 0-0-0-0 | IMC-01 |
| 417 | 4 | 6 | 50-0-0-20 | WESTAR |
| 418 | 4 | 3 | 100-20-0-20 | WESTAR |
| 419 | 4 | 7 | 50-40-0-20 | WESTAR |
| 420 | 4 | 2 | 50-20-0-20 | WESTAR |
| 421 | 4 | 4 | 50-20-0-0 | WESTAR |
| 422 | 4 | 8 | 17-20-0-20 | WESTAR |
| 423 | 4 | 5 | 50-20-0-40 | WESTAR |
| 424 | 4 | 1 | 0-0-0-0 | WESTAR |

## Table 16 ----continued.

Bozeman 1992

| PLOT | BLOCK | TREATMENT | NPKS | VARIETY | PLOT | BLOCK | TREATMENT | NPKS | VARIETY |
|---|---|---|---|---|---|---|---|---|---|
| 101 | 1 | 1 | 0-0-0-0 | WESTAR | 301 | 3 | 2 | 100-30-0-20 | IMC129 |
| 102 | 1 | 2 | 100-30-0-20 | WESTAR | 302 | 3 | 7 | 100-60-0-20 | IMC129 |
| 103 | 1 | 3 | 150-30-0-20 | WESTAR | 303 | 3 | 5 | 100-30-0-40 | IMC129 |
| 104 | 1 | 4 | 100-30-0-0 | WESTAR | 304 | 3 | 4 | 100-30-0-0 | IMC129 |
| 105 | 1 | 5 | 100-30-0-40 | WESTAR | 305 | 3 | 8 | 17-30-0-20 | IMC129 |
| 106 | 1 | 6 | 100-0-0-20 | WESTAR | 306 | 3 | 3 | 150-30-0-20 | IMC129 |
| 107 | 1 | 7 | 100-60-0-20 | WESTAR | 307 | 3 | 1 | 0-0-0-0 | IMC129 |
| 108 | 1 | 8 | 17-30-0-20 | WESTAR | 308 | 3 | 6 | 100-0-0-20 | IMC129 |
| 109 | 1 | 1 | 0-0-0-0 | IMC-01 | 309 | 3 | 7 | 100-60-0-20 | IMC-01 |
| 110 | 1 | 2 | 100-30-0-20 | IMC-01 | 310 | 3 | 8 | 17-30-0-20 | IMC-01 |
| 111 | 1 | 3 | 150-30-0-20 | IMC-01 | 311 | 3 | 4 | 100-30-0-0 | IMC-01 |
| 112 | 1 | 4 | 100-30-0-0 | IMC-01 | 312 | 3 | 2 | 100-30-0-20 | IMC-01 |
| 113 | 1 | 5 | 100-30-0-40 | IMC-01 | 313 | 3 | 5 | 100-30-0-40 | IMC-01 |
| 114 | 1 | 6 | 100-0-0-20 | IMC-01 | 314 | 3 | 6 | 100-0-0-20 | IMC-01 |
| 115 | 1 | 7 | 100-60-0-20 | IMC-01 | 315 | 3 | 3 | 150-30-0-20 | IMC-01 |
| 116 | 1 | 8 | 17-30-0-20 | IMC-01 | 316 | 3 | 1 | 0-0-0-0 | IMC-01 |
| 117 | 1 | 1 | 0-0-0-0 | IMC129 | 317 | 3 | 4 | 100-30-0-0 | WESTAR |
| 118 | 1 | 2 | 100-30-0-20 | IMC129 | 318 | 3 | 3 | 150-30-0-20 | WESTAR |
| 119 | 1 | 3 | 150-30-0-20 | IMC129 | 319 | 3 | 1 | 0-0-0-0 | WESTAR |
| 120 | 1 | 4 | 100-30-0-0 | IMC129 | 320 | 3 | 7 | 100-60-0-20 | WESTAR |
| 121 | 1 | 5 | 100-30-0-40 | IMC129 | 321 | 3 | 6 | 100-0-0-20 | WESTAR |
| 122 | 1 | 6 | 100-0-0-20 | IMC129 | 322 | 3 | 8 | 17-30-0-20 | WESTAR |
| 123 | 1 | 7 | 100-60-0-20 | IMC129 | 323 | 3 | 5 | 100-30-0-40 | WESTAR |
| 124 | 1 | 8 | 17-30-0-20 | IMC129 | 324 | 3 | 2 | 100-30-0- | WESTAR |
| 201 | 2 | 7 | 100-60-0-20 | IMC-01 | 401 | 4 | 8 | 17-30-0-20 | IMC-01 |
| 202 | 2 | 4 | 100-30-0-0 | IMC-01 | 402 | 4 | 2 | 100-30-0-20 | IMC-01 |
| 203 | 2 | 3 | 150-30-0-20 | IMC-01 | 403 | 4 | 5 | 100-30-0- | IMC-01 |
| 204 | 2 | 2 | 100-30-0-20 | IMC-01 | 404 | 4 | 4 | 100-30-0-0 | IMC-01 |
| 205 | 2 | 1 | 0-0-0-0 | IMC-01 | 405 | 4 | 7 | 100-60-0-20 | IMC-01 |
| 206 | 2 | 6 | 100-0-0-20 | IMC-01 | 406 | 4 | 3 | 150-30-0-20 | IMC-01 |
| 207 | 2 | 5 | 100-30-0-40 | IMC-01 | 407 | 4 | 1 | 0-0-0-0 | IMC-01 |
| 208 | 2 | 8 | 17-30-0-20 | IMC-01 | 408 | 4 | 6 | 100-0-0-20 | IMC-01 |
| 209 | 2 | 6 | 100-0-0-20 | IMC129 | 409 | 4 | 1 | 0-0-0-0 | WESTAR |
| 210 | 2 | 3 | 150-30-0-20 | IMC129 | 410 | 4 | 4 | 100-30-0-0 | WESTAR |
| 211 | 2 | 4 | 100-30-0-0 | IMC129 | 411 | 4 | 5 | 100-30-0-40 | WESTAR |
| 212 | 2 | 1 | 0-0-0-0 | IMC129 | 412 | 4 | 6 | 100-0-0-20 | WESTAR |
| 213 | 2 | 8 | 17-30-0-20 | IMC129 | 413 | 4 | 8 | 17-30-0-20 | WESTAR |
| 214 | 2 | 2 | 100-30-0-20 | IMC129 | 414 | 4 | 7 | 100-60-0-20 | WESTAR |
| 215 | 2 | 5 | 100-30-0-40 | IMC129 | 415 | 4 | 2 | 100-30-0-20 | WESTAR |
| 216 | 2 | 7 | 100-60-0-20 | IMC129 | 416 | 4 | 3 | 150-30-0-20 | WESTAR |
| 217 | 2 | 6 | 100-0-0-20 | WESTAR | 417 | 4 | 3 | 150-30-0-20 | IMC129 |
| 218 | 2 | 2 | 100-30-0-20 | WESTAR | 418 | 4 | 7 | 100-60-0-20 | IMC129 |
| 219 | 2 | 4 | 100-30-0-0 | WESTAR | 419 | 4 | 6 | 100-0-0-20 | IMC129 |
| 220 | 2 | 5 | 100-30-0-40 | WESTAR | 420 | 4 | 1 | 0-0-0-0 | IMC129 |
| 221 | 2 | 7 | 100-60-0-20 | WESTAR | 421 | 4 | 5 | 100-30-0-40 | IMC129 |
| 222 | 2 | 8 | 17-30-0-20 | WESTAR | 422 | 4 | 4 | 100-30-0-0 | IMC129 |
| 223 | 2 | 3 | 150-30-0-20 | WESTAR | 423 | 4 | 2 | 100-30-0-20 | IMC129 |
| 224 | 2 | 1 | 0-0-0-0 | WESTAR | 424 | 4 | 8 | 17-30-0-20 | IMC129 |

## Table 16 ----continued.

Fairfield 1993

| PLOT | BLOCK | TREATMENT | NPKS | VARIETY | PLOT | BLOCK | TREATMENT | NPKS | VARIETY |
|---|---|---|---|---|---|---|---|---|---|
| 101 | 1 | 5 | 100-30-0-40 | IMC129 | 301 | 3 | 5 | 100-30-0-40 | WESTAR |
| 102 | 1 | 3 | 150-30-0-20 | IMC129 | 302 | 3 | 7 | 100-60-0-20 | WESTAR |
| 103 | 1 | 6 | 100-0-0-20 | IMC129 | 303 | 3 | 2 | 100-30-0-20 | WESTAR |
| 104 | 1 | 7 | 100-60-0-20 | IMC129 | 304 | 3 | 8 | 17-30-0-20 | WESTAR |
| 105 | 1 | 5 | 100-30-0-40 | IMC-01 | 305 | 3 | 4 | 100-30-0-0 | IMC129 |
| 106 | 1 | 1 | 0-0-0-0 | IMC-01 | 306 | 3 | 2 | 100-30-0-20 | IMC129 |
| 107 | 1 | 6 | 100-0-0-20 | IMC-01 | 307 | 3 | 7 | 100-60-0-20 | IMC129 |
| 108 | 1 | 2 | 100-30-0-20 | IMC-01 | 308 | 3 | 5 | 100-30-0-40 | IMC129 |
| 109 | 1 | 1 | 0-0-0-0 | WESTAR | 309 | 3 | 4 | 100-30-0-0 | IMC-01 |
| 110 | 1 | 6 | 100-0-0-20 | WESTAR | 310 | 3 | 7 | 100-60-0-20 | IMC-01 |
| 111 | 1 | 5 | 100-30-0-40 | WESTAR | 311 | 3 | 2 | 100-30-0-20 | IMC-01 |
| 112 | 1 | 2 | 100-30-0-20 | WESTAR | 312 | 3 | 5 | 100-30-0-40 | IMC-01 |
| 113 | 1 | 2 | 100-30-0-20 | IMC129 | 313 | 3 | 3 | 150-30-0-20 | WESTAR |
| 114 | 1 | 8 | 17-30-0-20 | IMC129 | 314 | 3 | 6 | 100-0-0-20 | WESTAR |
| 115 | 1 | 4 | 100-30-0-0 | IMC129 | 315 | 3 | 1 | 0-0-0-0 | WESTAR |
| 116 | 1 | 1 | 0-0-0-0 | IMC129 | 316 | 3 | 4 | 100-30-0-0 | WESTAR |
| 117 | 1 | 8 | 17-30-0-20 | IMC-01 | 317 | 3 | 3 | 150-30-0-20 | IMC129 |
| 118 | 1 | 3 | 150-30-0-20 | IMC-01 | 318 | 3 | 8 | 17-30-0-20 | IMC129 |
| 119 | 1 | 7 | 100-60-0-20 | IMC-01 | 319 | 3 | 1 | 0-0-0-0 | IMC129 |
| 120 | 1 | 4 | 100-30-0-0 | IMC-01 | 320 | 3 | 6 | 100-0-0-20 | IMC129 |
| 121 | 1 | 4 | 100-30-0-0 | WESTAR | 321 | 3 | 3 | 150-30-0-20 | IMC-01 |
| 122 | 1 | 8 | 17-30-0-20 | WESTAR | 322 | 3 | 8 | 17-30-0-20 | IMC-01 |
| 123 | 1 | 3 | 150-30-0-20 | WESTAR | 323 | 3 | 1 | 0-0-0-0 | IMC-01 |
| 124 | 1 | 7 | 100-60-0-20 | WESTAR | 324 | 3 | 6 | 100-0-0-20 | IMC-01 |
| 201 | 2 | 6 | 100-0-0-20 | IMC-01 | 401 | 4 | 8 | 17-30-0-20 | IMC129 |
| 202 | 2 | 3 | 150-30-0-20 | IMC-01 | 402 | 4 | 7 | 100-60-0-20 | IMC129 |
| 203 | 2 | 8 | 17-30-0-20 | IMC-01 | 403 | 4 | 6 | 100-0-0-20 | IMC129 |
| 204 | 2 | 4 | 100-30-0-0 | IMC-01 | 404 | 4 | 5 | 100-30-0-40 | IMC129 |
| 205 | 2 | 3 | 150-30-0-20 | WESTAR | 405 | 4 | 8 | 17-30-0-20 | IMC-01 |
| 206 | 2 | 7 | 100-60-0-20 | WESTAR | 406 | 4 | 7 | 100-60-0-20 | IMC-01 |
| 207 | 2 | 2 | 100-30-0-20 | WESTAR | 407 | 4 | 6 | 100-0-0-20 | IMC-01 |
| 208 | 2 | 5 | 100-30-0-40 | WESTAR | 408 | 4 | 5 | 100-30-0-40 | IMC-01 |
| 209 | 2 | 3 | 150-30-0-20 | IMC129 | 409 | 4 | 8 | 17-30-0-20 | WESTAR |
| 210 | 2 | 1 | 0-0-0-0 | IMC129 | 410 | 4 | 7 | 100-60-0-20 | WESTAR |
| 211 | 2 | 7 | 100-60-0-20 | IMC129 | 411 | 4 | 6 | 100-0-0-20 | WESTAR |
| 212 | 2 | 4 | 100-30-0-0 | IMC129 | 412 | 4 | 5 | 100-30-0-40 | WESTAR |
| 213 | 2 | 7 | 100-60-0-20 | IMC-01 | 413 | 4 | 4 | 100-30-0-0 | IMC129 |
| 214 | 2 | 1 | 0-0-0-0 | IMC-01 | 414 | 4 | 3 | 150-30-0-20 | IMC129 |
| 215 | 2 | 5 | 100-30-0-40 | IMC-01 | 415 | 4 | 2 | 100-30-0-20 | IMC129 |
| 216 | 2 | 2 | 100-30-0-20 | IMC-01 | 416 | 4 | 1 | 0-0-0-0 | IMC129 |
| 217 | 2 | 8 | 17-30-0-20 | WESTAR | 417 | 4 | 4 | 100-30-0-0 | IMC-01 |
| 218 | 2 | 1 | 0-0-0-0 | WESTAR | 418 | 4 | 3 | 150-30-0-20 | IMC-01 |
| 219 | 2 | 4 | 100-30-0-0 | WESTAR | 419 | 4 | 2 | 100-30-0-20 | IMC-01 |
| 220 | 2 | 6 | 100-0-0-20 | WESTAR | 420 | 4 | 1 | 0-0-0-0 | IMC-01 |
| 221 | 2 | 8 | 17-30-0-20 | IMC129 | 421 | 4 | 4 | 100-30-0-0 | WESTAR |
| 222 | 2 | 6 | 100-0-0-20 | IMC129 | 422 | 4 | 3 | 150-30-0-20 | WESTAR |
| 223 | 2 | 2 | 100-30-0-20 | IMC129 | 423 | 4 | 2 | 100-30-0-20 | WESTAR |
| 224 | 2 | 5 | 100-30-0-40 | IMC129 | 424 | 4 | 1 | 0-0-0-0 | WESTAR |

## Table 16 ----continued.

Moccasin 1993

| PLOT | BLOCK | TREATMENT | NPKS | VARIETY |
|---|---|---|---|---|
| 101 | 1 | 1 | 0-0-0-0 | WESTAR |
| 102 | 1 | 2 | 50-20-0-20 | WESTAR |
| 103 | 1 | 3 | 100-20-0-20 | WESTAR |
| 104 | 1 | 4 | 50-20-0-0 | WESTAR |
| 105 | 1 | 5 | 50-20-0-40 | WESTAR |
| 106 | 1 | 6 | 50-0-0-20 | WESTAR |
| 107 | 1 | 7 | 50-40-0-20 | WESTAR |
| 108 | 1 | 8 | 17-20-0-20 | WESTAR |
| 109 | 1 | 1 | 0-0-0-0 | IMC-01 |
| 110 | 1 | 2 | 50-20-0-20 | IMC-01 |
| 111 | 1 | 3 | 100-20-0-20 | IMC-01 |
| 112 | 1 | 4 | 50-20-0-0 | IMC-01 |
| 113 | 1 | 5 | 50-20-0-40 | IMC-01 |
| 114 | 1 | 6 | 50-0-0-20 | IMC-01 |
| 115 | 1 | 7 | 50-40-0-20 | IMC-01 |
| 116 | 1 | 8 | 17-20-0-20 | IMC-01 |
| 117 | 1 | 1 | 0-0-0-0 | IMC129 |
| 118 | 1 | 2 | 50-20-0-20 | IMC129 |
| 119 | 1 | 3 | 100-20-0-20 | IMC129 |
| 120 | 1 | 4 | 50-20-0-0 | IMC129 |
| 121 | 1 | 5 | 50-20-0-40 | IMC129 |
| 122 | 1 | 6 | 50-0-0-20 | IMC129 |
| 123 | 1 | 7 | 50-40-0-20 | IMC129 |
| 124 | 1 | 8 | 17-20-0-20 | IMC129 |
| 201 | 2 | 3 | 100-20-0-20 | IMC-01 |
| 202 | 2 | 7 | 50-40-0-20 | IMC-01 |
| 203 | 2 | 1 | 0-0-0-0 | IMC-01 |
| 204 | 2 | 8 | 17-20-0-20 | IMC-01 |
| 205 | 2 | 2 | 50-20-0-20 | IMC-01 |
| 206 | 2 | 5 | 50-20-0-40 | IMC-01 |
| 207 | 2 | 4 | 50-20-0-0 | IMC-01 |
| 208 | 2 | 6 | 50-0-0-20 | IMC-01 |
| 209 | 2 | 3 | 100-20-0-20 | IMC129 |
| 210 | 2 | 7 | 50-40-0-20 | IMC129 |
| 211 | 2 | 1 | 0-0-0-0 | IMC129 |
| 212 | 2 | 8 | 17-20-0-20 | IMC129 |
| 213 | 2 | 2 | 50-20-0-20 | IMC129 |
| 214 | 2 | 5 | 50-20-0-40 | IMC129 |
| 215 | 2 | 4 | 50-20-0-0 | IMC129 |
| 216 | 2 | 6 | 50-0-0-20 | IMC129 |
| 217 | 2 | 3 | 100-20-0-20 | WESTAR |
| 218 | 2 | 7 | 50-40-0-20 | WESTAR |
| 219 | 2 | 1 | 0-0-0-0 | WESTAR |
| 220 | 2 | 8 | 17-20-0-20 | WESTAR |
| 221 | 2 | 2 | 50-20-0-20 | WESTAR |
| 222 | 2 | 5 | 50-20-0-40 | WESTAR |
| 223 | 2 | 4 | 50-20-0-0 | WESTAR |
| 224 | 2 | 6 | 50-0-0-20 | WESTAR |
| 301 | 3 | 8 | 17-20-0-20 | IMC129 |
| 302 | 3 | 6 | 50-0-0-20 | IMC129 |
| 303 | 3 | 4 | 50-20-0-0 | IMC129 |
| 304 | 3 | 5 | 50-20-0-4 | IMC129 |
| 305 | 3 | 1 | 0-0-0-0 | IMC129 |
| 306 | 3 | 3 | 100-20-0-20 | IMC129 |
| 307 | 3 | 7 | 50-40-0-20 | IMC129 |
| 308 | 3 | 2 | 50-20-0-20 | IMC129 |
| 309 | 3 | 8 | 17-20-0-20 | WESTAR |
| 310 | 3 | 6 | 50-0-0-20 | WESTAR |
| 311 | 3 | 4 | 50-20-0-0 | WESTAR |
| 312 | 3 | 5 | 50-20-0-40 | WESTAR |
| 313 | 3 | 1 | 0-0-0-0 | WESTAR |
| 314 | 3 | 3 | 100-20-0-20 | WESTAR |
| 315 | 3 | 7 | 50-40-0-20 | WESTAR |
| 316 | 3 | 2 | 50-20-0-20 | WESTAR |
| 317 | 3 | 8 | 17-20-0-20 | IMC-01 |
| 318 | 3 | 6 | 50-0-0-20 | IMC-01 |
| 319 | 3 | 4 | 50-20-0-0 | IMC-01 |
| 320 | 3 | 5 | 50-20-0-40 | IMC-01 |
| 321 | 3 | 1 | 0-0-0-0 | IMC-01 |
| 322 | 3 | 3 | 100-20-0-20 | IMC-01 |
| 323 | 3 | 7 | 50-40-0-20 | IMC-01 |
| 324 | 3 | 2 | 50-20-0-20 | IMC-01 |
| 401 | 4 | 6 | 50-0-0-20 | IMC129 |
| 402 | 4 | 3 | 100-20-0-20 | IMC129 |
| 403 | 4 | 7 | 50-40-0-20 | IMC129 |
| 404 | 4 | 2 | 50-20-0-20 | IMC129 |
| 405 | 4 | 4 | 50-20-0-0 | IMC129 |
| 406 | 4 | 8 | 17-20-0-20 | IMC129 |
| 407 | 4 | 5 | 50-20-0-40 | IMC129 |
| 408 | 4 | 1 | 0-0-0-0 | IMC129 |
| 409 | 4 | 6 | 50-0-0-20 | IMC-01 |
| 410 | 4 | 3 | 100-20-0-20 | IMC-01 |
| 411 | 4 | 7 | 50-40-0-20 | IMC-01 |
| 412 | 4 | 2 | 50-20-0-20 | IMC-01 |
| 413 | 4 | 4 | 50-20-0-0 | IMC-01 |
| 414 | 4 | 8 | 17-20-0-20 | IMC-01 |
| 415 | 4 | 5 | 50-20-0-40 | IMC-01 |
| 416 | 4 | 1 | 0-0-0-0 | IMC-01 |
| 417 | 4 | 6 | 50-0-0-20 | WESTAR |
| 418 | 4 | 3 | 100-20-0-20 | WESTAR |
| 419 | 4 | 7 | 50-40-0-20 | WESTAR |
| 420 | 4 | 2 | 50-20-0-20 | WESTAR |
| 421 | 4 | 4 | 50-20-0-0 | WESTAR |
| 422 | 4 | 8 | 17-20-0-20 | WESTAR |
| 423 | 4 | 5 | 50-20-0-40 | WESTAR |
| 424 | 4 | 1 | 0-0-0-0 | WESTAR |

## Table 16 ----continued.

Bozeman 1993

| PLOT | BLOCK | TREATMENT | NPKS | VARIETY |
|---|---|---|---|---|
| 101 | 1 | 1 | 0-0-0-0 | WESTAR |
| 102 | 1 | 2 | 100-30-0-20 | WESTAR |
| 103 | 1 | 3 | 150-30-0-20 | WESTAR |
| 104 | 1 | 4 | 100-30-0-0 | WESTAR |
| 105 | 1 | 5 | 100-30-0-40 | WESTAR |
| 106 | 1 | 6 | 100-0-0-20 | WESTAR |
| 107 | 1 | 7 | 100-60-0-20 | WESTAR |
| 108 | 1 | 8 | 17-30-0-20 | WESTAR |
| 109 | 1 | 1 | 0-0-0-0 | IMC-01 |
| 110 | 1 | 2 | 100-30-0-20 | IMC-01 |
| 111 | 1 | 3 | 150-30-0-20 | IMC-01 |
| 112 | 1 | 4 | 100-30-0-0 | IMC-01 |
| 113 | 1 | 5 | 100-30-0-40 | IMC-01 |
| 114 | 1 | 6 | 100-0-0-20 | IMC-01 |
| 115 | 1 | 7 | 100-60-0-20 | IMC-01 |
| 116 | 1 | 8 | 17-30-0-20 | IMC-01 |
| 117 | 1 | 1 | 0-0-0-0 | IMC129 |
| 118 | 1 | 2 | 100-30-0-20 | IMC129 |
| 119 | 1 | 3 | 150-30-0-20 | IMC129 |
| 120 | 1 | 4 | 100-30-0-0 | IMC129 |
| 121 | 1 | 5 | 100-30-0-40 | IMC129 |
| 122 | 1 | 6 | 100-0-0-20 | IMC129 |
| 123 | 1 | 7 | 100-60-0-20 | IMC129 |
| 124 | 1 | 8 | 17-30-0-20 | IMC129 |
| 201 | 2 | 7 | 100-60-0-20 | IMC-01 |
| 202 | 2 | 4 | 100-30-0-0 | IMC-01 |
| 203 | 2 | 3 | 150-30-0-20 | IMC-01 |
| 204 | 2 | 2 | 100-30-0-20 | IMC-01 |
| 205 | 2 | 1 | 0-0-0-0 | IMC-01 |
| 206 | 2 | 6 | 100-0-0-20 | IMC-01 |
| 207 | 2 | 5 | 100-30-0-40 | IMC-01 |
| 208 | 2 | 8 | 17-30-0-20 | IMC-01 |
| 209 | 2 | 6 | 100-0-0-20 | IMC129 |
| 210 | 2 | 3 | 150-30-0-20 | IMC129 |
| 211 | 2 | 4 | 100-30-0-0 | IMC129 |
| 212 | 2 | 1 | 0-0-0-0 | IMC129 |
| 213 | 2 | 8 | 17-30-0-20 | IMC129 |
| 214 | 2 | 2 | 100-30-0-20 | IMC129 |
| 215 | 2 | 5 | 100-30-0-40 | IMC129 |
| 216 | 2 | 7 | 100-60-0-20 | IMC129 |
| 217 | 2 | 6 | 100-0-0-20 | WESTAR |
| 218 | 2 | 2 | 100-30-0-20 | WESTAR |
| 219 | 2 | 4 | 100-30-0-0 | WESTAR |
| 220 | 2 | 5 | 100-30-0-40 | WESTAR |
| 221 | 2 | 7 | 100-60-0-20 | WESTAR |
| 222 | 2 | 8 | 17-30-0-20 | WESTAR |
| 223 | 2 | 3 | 150-30-0-20 | WESTAR |
| 224 | 2 | 1 | 0-0-0-0 | WESTAR |
| 301 | 3 | 2 | 100-30-0-20 | IMC129 |
| 302 | 3 | 7 | 100-60-0-20 | IMC129 |
| 303 | 3 | 5 | 100-30-0-40 | IMC129 |
| 304 | 3 | 4 | 100-30-0-0 | IMC129 |
| 305 | 3 | 8 | 17-30-0-20 | IMC129 |
| 306 | 3 | 3 | 150-30-0-20 | IMC129 |
| 307 | 3 | 1 | 0-0-0-0 | IMC129 |
| 308 | 3 | 6 | 100-0-0-20 | IMC129 |
| 309 | 3 | 7 | 100-60-0-20 | IMC-01 |
| 310 | 3 | 8 | 17-30-0-20 | IMC-01 |
| 311 | 3 | 4 | 100-30-0-0 | IMC-01 |
| 312 | 3 | 2 | 100-30-0-20 | IMC-01 |
| 313 | 3 | 5 | 100-30-0-40 | IMC-01 |
| 314 | 3 | 6 | 100-0-0-20 | IMC-01 |
| 315 | 3 | 3 | 150-30-0-20 | IMC-01 |
| 316 | 3 | 1 | 0-0-0-0 | IMC-01 |
| 317 | 3 | 4 | 100-30-0-0 | WESTAR |
| 318 | 3 | 3 | 150-30-0-20 | WESTAR |
| 319 | 3 | 1 | 0-0-0-0 | WESTAR |
| 320 | 3 | 7 | 100-60-0-20 | WESTAR |
| 321 | 3 | 6 | 100-0-0-20 | WESTAR |
| 322 | 3 | 8 | 17-30-0-20 | WESTAR |
| 323 | 3 | 5 | 100-30-0-40 | WESTAR |
| 324 | 3 | 2 | 100-30-0- | WESTAR |
| 401 | 4 | 8 | 17-30-0-20 | IMC-01 |
| 402 | 4 | 2 | 100-30-0-20 | IMC-01 |
| 403 | 4 | 5 | 100-30-0- | IMC-01 |
| 404 | 4 | 4 | 100-30-0-0 | IMC-01 |
| 405 | 4 | 7 | 100-60-0-20 | IMC-01 |
| 406 | 4 | 3 | 150-30-0-20 | IMC-01 |
| 407 | 4 | 1 | 0-0-0-0 | IMC-01 |
| 408 | 4 | 6 | 100-0-0-20 | IMC-01 |
| 409 | 4 | 1 | 0-0-0-0 | WESTAR |
| 410 | 4 | 4 | 100-30-0-0 | WESTAR |
| 411 | 4 | 5 | 100-30-0-40 | WESTAR |
| 412 | 4 | 6 | 100-0-0-20 | WESTAR |
| 413 | 4 | 8 | 17-30-0-20 | WESTAR |
| 414 | 4 | 7 | 100-60-0-20 | WESTAR |
| 415 | 4 | 2 | 100-30-0-20 | WESTAR |
| 416 | 4 | 3 | 150-30-0-20 | WESTAR |
| 417 | 4 | 3 | 150-30-0-20 | IMC129 |
| 418 | 4 | 7 | 100-60-0-20 | IMC129 |
| 419 | 4 | 6 | 100-0-0-20 | IMC129 |
| 420 | 4 | 1 | 0-0-0-0 | IMC129 |
| 421 | 4 | 5 | 100-30-0-40 | IMC129 |
| 422 | 4 | 4 | 100-30-0-0 | IMC129 |
| 423 | 4 | 2 | 100-30-0-20 | IMC129 |
| 424 | 4 | 8 | 17-30-0-20 | IMC129 |

# Table 17. 1992 Fatty-Acid Profiles (%)

## Fairfield 1992

| PLOT | % OIL | C:18:1 | C:18:3 | C:22:1 |
|---|---|---|---|---|
| 101 | 45.2 | 63.30 | 8.75 | |
| 102 | 46.5 | 63.27 | 9.25 | |
| 103 | 44.0 | 57.17 | 8.17 | |
| 104 | 44.7 | 62.54 | 8.12 | |
| 105 | 44.5 | 63.17 | 5.83 | |
| 106 | 44.9 | 60.68 | 5.67 | |
| 107 | 42.1 | 60.02 | 7.39 | 0.24 |
| 108 | 40.5 | 61.91 | 6.51 | |
| 109 | 47.6 | 74.18 | 7.26 | |
| 110 | 45.3 | 74.55 | 6.91 | |
| 111 | 44.4 | 76.45 | 6.82 | |
| 112 | 46.8 | 75.55 | 7.18 | |
| 113 | 45.3 | 64.58 | 8.75 | |
| 114 | 46.3 | 64.63 | 8.41 | |
| 115 | 46.5 | 57.16 | 8.19 | 3.80 |
| 116 | 46.8 | 60.28 | 8.26 | 1.39 |
| 117 | 43.1 | 60.67 | 6.30 | |
| 118 | 45.6 | 61.38 | 6.08 | |
| 119 | 44.6 | 61.99 | 6.28 | |
| 120 | 43.5 | 62.36 | 5.29 | |
| 121 | 44.9 | 73.91 | 7.17 | |
| 122 | 46.7 | 76.06 | 6.91 | |
| 123 | 46.5 | 75.13 | 7.19 | |
| 124 | 46.9 | 75.56 | 6.93 | |
| 201 | 43.9 | 62.24 | 6.15 | |
| 202 | 44.9 | 63.22 | 6.14 | |
| 203 | 44.2 | 62.98 | 6.32 | |
| 204 | 41.2 | 62.23 | 5.53 | |
| 205 | 46.5 | 75.66 | 7.26 | |
| 206 | 47.4 | 75.66 | 7.59 | |
| 207 | 46.4 | 75.71 | 7.28 | |
| 208 | 44.0 | 74.42 | 7.04 | |
| 209 | 42.9 | 61.89 | 9.07 | 0.38 |
| 210 | 45.5 | 65.08 | 8.77 | |
| 211 | 43.4 | 63.21 | 8.75 | 0.47 |
| 212 | 43.1 | 60.46 | 9.03 | 0.80 |
| 213 | 42.6 | 61.67 | 6.39 | |
| 214 | 42.5 | 61.57 | 5.79 | |
| 215 | 42.2 | 61.66 | 6.03 | |
| 216 | 43.1 | 61.55 | 6.77 | |
| 217 | 46.4 | 74.26 | 7.72 | |
| 218 | 45.4 | 76.00 | 7.07 | |
| 219 | 47.0 | 74.28 | 7.03 | 0.61 |
| 220 | 45.5 | 75.35 | 6.40 | |
| 221 | 44.9 | 60.40 | 9.88 | 0.96 |
| 222 | 44.9 | 65.64 | 8.23 | |
| 223 | 44.2 | 64.39 | 8.66 | |
| 224 | 44.7 | 59.23 | 8.50 | 3.30 |
| 301 | 47.4 | 76.14 | 7.38 | |
| 302 | 44.9 | 73.12 | 7.90 | |
| 303 | 46.9 | 76.49 | 6.89 | |
| 304 | 47.0 | 75.87 | 7.49 | |
| 305 | 45.9 | 63.58 | 8.86 | |
| 306 | 44.4 | 65.47 | 7.91 | |
| 307 | 45.1 | 62.44 | 9.53 | 2.91 |
| 308 | 46.9 | 58.74 | 8.65 | |
| 309 | 42.1 | 61.97 | 7.31 | |
| 310 | 42.5 | 61.51 | 7.38 | |
| 311 | 44.1 | 62.37 | 7.03 | |
| 312 | 39.7 | 60.83 | 6.81 | |
| 313 | 45.6 | 75.91 | 7.05 | |
| 314 | 46.4 | 74.28 | 7.60 | |
| 315 | 47.2 | 75.09 | 7.64 | |
| 316 | 45.4 | 75.99 | 6.90 | |
| 317 | 42.1 | 63.87 | 8.28 | |
| 318 | 43.0 | 63.31 | 8.80 | |
| 319 | 43.4 | 60.37 | 8.50 | 1.30 |
| 320 | 42.7 | 62.91 | 9.49 | |
| 321 | 45.3 | 62.95 | 8.91 | |
| 322 | 40.0 | 59.89 | 6.20 | |
| 323 | 42.9 | 62.62 | 6.63 | |
| 324 | 42.3 | 62.37 | 6.26 | |
| 401 | 45.1 | 64.58 | 8.86 | |
| 402 | 44.0 | 59.65 | 8.32 | 1.45 |
| 403 | 43.7 | 60.26 | 9.46 | 1.66 |
| 404 | 46.2 | 64.51 | 8.82 | |
| 405 | 42.6 | 61.12 | 6.40 | |
| 406 | 40.8 | 60.29 | 7.46 | |
| 407 | 41.5 | 60.70 | 6.47 | |
| 408 | 44.2 | 62.16 | 6.91 | |
| 409 | 47.4 | 75.37 | 7.38 | |
| 410 | 46.5 | 75.63 | 7.32 | |
| 411 | 47.7 | 76.59 | 7.09 | |
| 412 | 46.5 | 74.86 | 7.66 | |
| 413 | 45.2 | 65.42 | 8.63 | |
| 414 | 45.1 | 63.05 | 9.17 | |
| 415 | 46.8 | 62.38 | 8.60 | 1.51 |
| 416 | 45.7 | 63.99 | 9.16 | |
| 417 | 38.1 | 59.93 | 6.15 | |
| 418 | 45.9 | 62.12 | 6.41 | |
| 419 | 41.0 | 61.33 | 4.98 | |
| 420 | 43.2 | 66.00 | 5.64 | |
| 421 | 46.2 | 75.67 | 7.42 | |
| 422 | 46.2 | 75.56 | 7.16 | |
| 423 | 45.6 | 76.17 | 7.13 | |
| 424 | 44.3 | 75.88 | 6.62 | |

## Table 17 (continued)

### Moccasin 1992

| PLOT | % OIL | C:18:1 | C:18:3 | C:22:1 | PLOT | % OIL | C:18:1 | C:18:3 | C:22:1 |
|---|---|---|---|---|---|---|---|---|---|
| 101 | 45.4 | 64.62 | 8.32 | | 303 | 43.9 | 74.00 | 5.39 | |
| 102 | 44.4 | 65.27 | 7.43 | | 304 | 44.3 | 76.68 | 5.77 | |
| 103 | 41.4 | 64.12 | 7.61 | | 305 | 45.1 | 77.15 | 6.10 | |
| 104 | 43.8 | 65.35 | 6.90 | | 306 | 40.9 | 75.51 | 5.11 | |
| 105 | 44.4 | 65.67 | 7.30 | | 307 | 44.3 | 76.08 | 5.85 | |
| 106 | 37.4 | 65.96 | 7.07 | | 308 | 43.5 | 76.16 | 6.15 | |
| 107 | 44.6 | 64.17 | 7.59 | | 309 | 44.7 | 64.71 | 7.67 | |
| 108 | 45.6 | 65.33 | 7.40 | | 310 | 43.3 | 65.62 | 7.09 | |
| 109 | 42.3 | 62.17 | 5.26 | | 311 | 43.6 | 65.21 | 6.55 | |
| 110 | 41.2 | 62.36 | 5.81 | | 312 | 43.4 | 63.18 | 7.39 | 0.61 |
| 111 | 39.5 | 61.27 | 5.13 | | 313 | 44.9 | 65.38 | 7.21 | |
| 114 | 41.6 | 61.58 | 5.64 | | 314 | 41.2 | 65.84 | 6.52 | |
| 115 | 41.1 | 61.99 | 5.31 | | 315 | 43.5 | 67.62 | 7.27 | |
| 116 | 41.9 | 62.29 | 5.67 | | 316 | 43.2 | 63.20 | 7.25 | 1.08 |
| 117 | 45.9 | 76.12 | 6.38 | | 317 | 41.7 | 61.17 | 7.02 | |
| 118 | 44.5 | 76.51 | 5.96 | | 318 | 40.6 | 60.39 | 5.40 | |
| 119 | 41.2 | 76.42 | 5.11 | | 319 | 40.5 | 62.70 | 4.84 | |
| 120 | 43.8 | 75.34 | 6.19 | | 320 | 41.1 | 63.61 | 5.94 | |
| 121 | 44.6 | 76.37 | 5.70 | | 321 | 40.5 | 60.97 | 6.05 | |
| 122 | 44.3 | 76.64 | 5.53 | | 322 | 39.2 | 61.52 | 4.80 | |
| 123 | 44.3 | 75.82 | 5.55 | | 323 | 41.1 | 62.46 | 5.69 | |
| 124 | 45.5 | 75.97 | 6.42 | | 324 | 41.3 | 63.25 | 5.68 | |
| 201 | 38.7 | 63.52 | 5.89 | | 401 | 38.8 | 74.82 | 5.02 | |
| 202 | 39.5 | 62.70 | 5.14 | | 402 | 36.3 | 75.36 | 4.79 | |
| 203 | 39.8 | 61.38 | 6.01 | | 403 | 40.5 | 76.93 | 5.03 | |
| 205 | 40.5 | 63.55 | 6.37 | | 404 | 40.6 | 61.57 | 5.49 | |
| 206 | 41.4 | 64.71 | 5.62 | | 405 | 43.1 | 76.04 | 5.44 | |
| 207 | 40.5 | 65.01 | 5.90 | | 406 | 44.5 | 76.51 | 5.72 | |
| 208 | 40.0 | 62.96 | 5.26 | | 407 | 43.2 | 76.19 | 5.80 | |
| 209 | 42.7 | 75.88 | 5.70 | | 408 | 45.3 | 76.71 | 5.54 | |
| 210 | 44.9 | 77.67 | 5.50 | | 409 | 39.9 | 61.91 | 5.29 | |
| 211 | 46.0 | 76.08 | 6.51 | | 410 | 38.2 | 62.06 | 5.21 | |
| 212 | 44.8 | 77.24 | 5.69 | | 411 | 40.9 | 62.91 | 5.12 | |
| 213 | 45.9 | 76.87 | 6.35 | | 412 | 42.2 | 76.53 | 4.95 | |
| 214 | 44.9 | 77.41 | 6.19 | | 413 | 40.3 | 62.44 | 5.39 | |
| 216 | 44.4 | 76.79 | 5.78 | 0.05 | 414 | 41.6 | 59.77 | 5.83 | |
| 217 | 42.0 | 65.57 | 7.29 | | 415 | 40.7 | 62.29 | 5.38 | 1.00 |
| 218 | 44.0 | 63.85 | 8.26 | | 416 | 42.0 | 59.14 | 5.59 | |
| 219 | 44.9 | 65.68 | 8.30 | | 417 | 42.7 | 64.29 | 7.32 | |
| 220 | 44.7 | 64.57 | 7.46 | | 418 | 40.1 | 64.26 | 6.66 | |
| 221 | 43.9 | 66.32 | 6.88 | | 419 | 43.0 | 61.33 | 6.46 | 2.58 |
| 222 | 44.4 | 63.73 | 6.90 | 0.67 | 420 | 43.3 | 63.78 | 7.59 | |
| 223 | 44.2 | 66.99 | 6.90 | | 421 | 43.1 | 65.20 | 7.37 | |
| 224 | 44.1 | 65.11 | 7.00 | | 422 | 44.6 | 65.96 | 7.26 | |
| 301 | 45.3 | 75.64 | 5.72 | | 423 | 43.8 | 62.43 | 7.58 | 0.59 |
| 302 | 44.0 | 76.74 | 5.64 | | 424 | 44.9 | 64.42 | 8.29 | |

# Table 17 (continued)

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| PLOT | % OIL | C:18:1 | C:18:3 | C:22:1 |
|---|---|---|---|---|
| 101 | 39.2 | 67.16 | 6.26 | |
| 102 | 36.5 | 66.96 | 6.02 | |
| 104 | 35.9 | 66.11 | 6.28 | |
| 105 | 36.6 | 66.36 | 6.81 | |
| 106 | 36.8 | 66.02 | 6.76 | |
| 107 | 37.3 | 68.24 | 5.19 | |
| 108 | 41.6 | 65.82 | 7.10 | |
| 109 | 41.8 | 63.90 | 5.62 | 0.16 |
| 110 | 38.5 | 63.78 | 4.98 | |
| 111 | 38.6 | 64.64 | 5.65 | |
| 112 | 39.5 | 63.15 | 5.74 | |
| 113 | 37.5 | 64.32 | 5.07 | |
| 114 | 39.9 | 63.83 | 6.25 | |
| 115 | 40.9 | 64.76 | 5.57 | |
| 116 | 42.5 | 65.84 | 5.65 | |
| 117 | 45.0 | 76.29 | 5.85 | |
| 118 | 41.7 | 77.51 | 5.66 | |
| 119 | 39.1 | 77.73 | 7.77 | |
| 120 | 40.2 | 76.80 | 4.91 | |
| 121 | 43.3 | 78.31 | 4.85 | |
| 122 | 41.9 | 77.89 | 4.89 | |
| 123 | 42.5 | 76.13 | 5.63 | |
| 124 | 43.6 | 77.29 | 5.72 | |
| 201 | 38.0 | 64.94 | 6.09 | |
| 202 | 38.9 | 63.93 | 4.95 | |
| 203 | 39.3 | 64.34 | 6.13 | |
| 204 | 40.5 | 66.07 | 4.54 | |
| 205 | 42.7 | 65.04 | 5.90 | |
| 206 | 40.4 | 65.90 | 5.05 | |
| 207 | 39.7 | 63.99 | 5.39 | |
| 208 | 44.3 | 64.74 | 5.63 | |
| 209 | 41.0 | 75.50 | 5.40 | |
| 210 | 40.8 | 75.89 | 5.35 | |
| 211 | 43.2 | 74.95 | 5.33 | |
| 212 | 43.7 | 70.43 | 5.30 | |
| 213 | 45.0 | 77.51 | 5.73 | |
| 214 | 43.2 | 75.79 | 5.09 | 0.08 |
| 215 | 42.4 | 76.45 | 4.45 | 0.18 |
| 216 | 42.1 | 75.35 | 5.33 | |
| 217 | 42.3 | 64.58 | 5.99 | 0.99 |
| 218 | 42.7 | 64.60 | 6.73 | 0.83 |
| 219 | 39.9 | 65.51 | 6.72 | 1.88 |
| 220 | 41.4 | 61.80 | 7.19 | |
| 221 | 41.0 | 67.45 | 6.55 | |
| 222 | 44.2 | 65.29 | 7.50 | |
| 223 | 41.1 | 66.97 | 7.16 | |
| 224 | 44.3 | 67.84 | 6.70 | |

| PLOT | % OIL | C:18:1 | C:18:3 | C:22:1 |
|---|---|---|---|---|
| 301 | 40.7 | 78.09 | 5.01 | |
| 302 | 41.1 | 77.65 | 5.13 | |
| 303 | 42.8 | 77.93 | 5.29 | |
| 304 | 42.2 | 77.82 | 4.74 | |
| 305 | 46.2 | 77.08 | 5.91 | |
| 306 | 41.3 | 78.83 | 4.61 | |
| 307 | 45.0 | 75.85 | 6.03 | |
| 308 | 41.8 | 77.63 | 5.84 | |
| 309 | 42.5 | 65.24 | 6.24 | |
| 310 | 44.5 | 63.87 | 6.41 | |
| 311 | 42.5 | 67.77 | 5.24 | 0.09 |
| 312 | 41.3 | 64.35 | 6.03 | |
| 313 | 42.6 | 64.79 | 4.98 | |
| 314 | 40.2 | 61.96 | 5.85 | |
| 315 | 42.2 | 64.33 | 5.76 | |
| 316 | 42.7 | 61.65 | 5.85 | 0.13 |
| 317 | 44.0 | 64.87 | 6.65 | 0.87 |
| 318 | 43.3 | 66.05 | 7.00 | |
| 319 | 45.1 | 66.96 | 7.41 | |
| 320 | 43.5 | 66.19 | 6.93 | |
| 321 | 43.0 | 67.14 | 6.86 | |
| 322 | 43.2 | 66.96 | 7.20 | |
| 323 | 43.0 | 66.33 | 7.20 | |
| 324 | 42.4 | 66.53 | 6.95 | |
| 401 | 44.0 | 66.57 | 5.87 | |
| 402 | 42.9 | 63.00 | 5.74 | |
| 403 | 43.2 | 64.82 | 5.41 | |
| 404 | 41.9 | 60.27 | 5.88 | 0.21 |
| 405 | 43.3 | 65.76 | 5.62 | |
| 406 | 42.1 | 65.18 | 5.53 | |
| 407 | 41.8 | 63.69 | 6.35 | |
| 408 | 41.6 | 63.38 | 5.68 | |
| 409 | 46.0 | 65.77 | 7.51 | |
| 410 | 42.2 | 64.28 | 6.92 | |
| 411 | 43.4 | 65.39 | 7.70 | |
| 412 | 42.1 | 62.54 | 6.98 | 0.99 |
| 413 | 40.9 | 66.27 | 6.81 | |
| 414 | 40.7 | 66.72 | 6.56 | |
| 415 | 41.3 | 67.86 | 6.42 | |
| 416 | 39.4 | 66.40 | 7.12 | |
| 417 | 41.8 | 77.22 | 4.80 | |
| 418 | 43.4 | 76.36 | 5.38 | |
| 419 | 43.4 | 77.40 | 5.69 | |
| 420 | 45.3 | 75.84 | 5.68 | |
| 421 | 43.2 | 78.45 | 5.37 | |
| 422 | 42.8 | 78.15 | 5.41 | |
| 423 | 37.3 | 76.57 | 5.96 | |
| 424 | 39.4 | 75.29 | 5.77 | |

**Table 18. 1993 Fatty-Acid Profiles (%)**

| LOC | sample # | NMR% | C14:0 | C16:0 | C16:1 | C18:0 | C18:1 | C18:2 | C18:3 | C20:0 | C20:1 | C20:2 | C22:0 | C22:1 | C24:0 | C24:1 | FDA sats |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fairfield | 101 | 44.3 | 0.05 | 3.69 | 0.25 | 1.89 | 66.47 | 16.64 | 08.56 | 0.64 | 1.10 | 0.09 | 0.39 | 0.04 | 0.17 | 0.02 | 5.63 |
| Fairfield | 102 | 42.2 | 0.05 | 3.78 | 0.26 | 1.85 | 63.59 | 17.67 | 08.26 | 0.63 | 1.85 | 0.12 | 0.40 | 1.33 | 0.20 | 0.02 | 5.68 |
| Fairfield | 103 | 44.1 | 0.05 | 3.70 | 0.24 | 1.73 | 65.60 | 17.33 | 09.01 | 0.60 | 1.09 | 0.10 | 0.37 | 0.05 | 0.12 | 0.01 | 5.47 |
| Fairfield | 104 | 43.0 | 0.05 | 3.90 | 0.26 | 1.81 | 64.10 | 18.14 | 09.08 | 0.63 | 1.14 | 0.11 | 0.40 | 0.05 | 0.14 | 0.19 | 5.76 |
| Fairfield | 105 | 41.6 | 0.05 | 4.09 | 0.26 | 1.84 | 60.97 | 24.04 | 06.06 | 0.65 | 1.12 | 0.13 | 0.41 | 0.07 | 0.16 | 0.18 | 5.98 |
| Fairfield | 106 | 44.7 | 0.05 | 3.88 | 0.24 | 1.95 | 63.86 | 22.35 | 05.38 | 0.61 | 0.94 | 0.09 | 0.36 | 0.05 | 0.11 | 0.13 | 5.88 |
| Fairfield | 107 | 44.5 | 0.06 | 4.00 | 0.24 | 1.95 | 64.04 | 22.23 | 05.11 | 0.62 | 0.95 | 0.07 | 0.38 | 0.05 | 0.14 | 0.15 | 6.01 |
| Fairfield | 108 | 44.6 | 0.05 | 3.97 | 0.24 | 1.91 | 64.02 | 22.46 | 05.00 | 0.64 | 1.01 | 0.11 | 0.38 | 0.06 | 0.14 | 0.02 | 5.93 |
| Fairfield | 109 | 47.0 | 0.05 | 3.34 | 0.25 | 1.87 | 76.24 | 07.35 | 06.57 | 0.60 | 1.05 | 0.07 | 0.33 | 0.06 | 0.10 | 0.12 | 5.26 |
| Fairfield | 110 | 47.4 | 0.05 | 3.36 | 0.26 | 1.95 | 77.57 | 07.86 | 06.59 | 0.61 | 1.06 | 0.07 | 0.33 | 0.06 | 0.11 | 0.12 | 5.37 |
| Fairfield | 111 | 47.9 | 0.05 | 3.41 | 0.26 | 1.77 | 77.91 | 07.84 | 06.55 | 0.58 | 1.04 | 0.08 | 0.33 | 0.06 | 0.11 | 0.02 | 5.23 |
| Fairfield | 112 | 46.9 | 0.05 | 3.33 | 0.25 | 1.84 | 77.93 | 07.59 | 06.72 | 0.60 | 1.07 | 0.07 | 0.34 | 0.07 | 0.12 | 0.02 | 5.22 |
| Fairfield | 113 | 41.2 | 0.05 | 3.69 | 0.25 | 2.01 | 63.57 | 17.11 | 08.90 | 0.68 | 1.79 | 0.13 | 0.44 | 0.96 | 0.18 | 0.23 | 5.75 |
| Fairfield | 114 | 45.3 | 0.05 | 3.70 | 0.25 | 1.95 | 66.96 | 16.33 | 08.24 | 0.63 | 1.07 | 0.12 | 0.37 | 0.07 | 0.12 | 0.15 | 5.70 |
| Fairfield | 115 | 44.4 | 0.05 | 3.89 | 0.26 | 1.90 | 63.34 | 17.41 | 08.97 | 0.66 | 1.94 | 0.14 | 0.40 | 0.69 | 0.15 | 0.20 | 5.85 |
| Fairfield | 116 | 44.6 | 0.05 | 3.66 | 0.23 | 1.80 | 64.58 | 17.33 | 08.81 | 0.60 | 1.71 | 0.12 | 0.35 | 0.61 | 0.14 | 0.01 | 5.51 |
| Fairfield | 117 | 45.1 | 0.05 | 3.93 | 0.23 | 2.02 | 64.38 | 21.81 | 05.20 | 0.64 | 0.95 | 0.09 | 0.37 | 0.05 | 0.13 | 0.14 | 6.00 |
| Fairfield | 118 | 43.1 | 0.06 | 3.98 | 0.26 | 1.88 | 61.88 | 23.46 | 05.95 | 0.65 | 1.10 | 0.10 | 0.31 | 0.07 | 0.14 | 0.17 | 5.92 |
| Fairfield | 119 | 42.4 | 0.05 | 4.03 | 0.27 | 1.80 | 61.80 | 23.60 | 05.87 | 0.65 | 1.12 | 0.11 | 0.31 | 0.05 | 0.14 | 0.19 | 5.88 |
| Fairfield | 120 | 43.0 | 0.06 | 3.95 | 0.27 | 1.91 | 62.50 | 22.84 | 05.87 | 0.68 | 1.12 | 0.10 | 0.32 | 0.05 | 0.16 | 0.18 | 5.91 |
| Fairfield | 121 | 45.9 | 0.05 | 3.37 | 0.26 | 1.77 | 76.63 | 08.73 | 06.77 | 0.62 | 1.18 | 0.07 | 0.26 | 0.06 | 0.11 | 0.14 | 5.18 |
| Fairfield | 122 | 46.5 | 0.06 | 3.31 | 0.27 | 1.87 | 77.62 | 07.71 | 06.86 | 0.63 | 1.13 | 0.08 | 0.26 | 0.06 | 0.13 | 0.02 | 5.24 |
| Fairfield | 123 | 46.2 | 0.05 | 3.20 | 0.26 | 1.82 | 78.45 | 07.24 | 06.35 | 0.64 | 1.26 | 0.09 | 0.29 | 0.06 | 0.14 | 0.14 | 5.07 |
| Fairfield | 124 | 46.4 | 0.05 | 3.41 | 0.27 | 1.82 | 77.11 | 08.36 | 06.54 | 0.64 | 1.24 | 0.06 | 0.28 | 0.08 | 0.13 | 0.02 | 5.27 |
| Fairfield | 201 | 41.4 | 0.06 | 4.00 | 0.26 | 1.90 | 62.16 | 22.88 | 06.01 | 0.68 | 1.20 | 0.11 | 0.33 | 0.05 | 0.17 | 0.19 | 5.97 |
| Fairfield | 202 | 42.8 | 0.06 | 3.98 | 0.26 | 1.86 | 61.68 | 23.66 | 05.96 | 0.66 | 1.10 | 0.09 | 0.31 | 0.06 | 0.15 | 0.18 | 5.90 |
| Fairfield | 203 | 44.8 | 0.05 | 3.85 | 0.25 | 2.02 | 64.31 | 21.59 | 05.69 | 0.66 | 1.01 | 0.09 | 0.29 | 0.06 | 0.12 | 0.02 | 5.92 |
| Fairfield | 204 | 44.0 | 0.05 | 3.79 | 0.24 | 1.95 | 65.13 | 20.54 | 05.78 | 0.66 | 1.11 | 0.09 | 0.30 | 0.06 | 0.14 | 0.16 | 5.79 |
| Fairfield | 205 | 44.1 | 0.05 | 3.38 | 0.27 | 1.69 | 75.85 | 08.66 | 07.42 | 0.64 | 1.31 | 0.08 | 0.29 | 0.07 | 0.14 | 0.18 | 5.12 |
| Fairfield | 206 | 43.6 | 0.05 | 3.40 | 0.27 | 1.66 | 76.36 | 08.23 | 07.37 | 0.62 | 1.31 | 0.08 | 0.28 | 0.07 | 0.13 | 0.17 | 5.11 |
| Fairfield | 207 | 44.8 | 0.05 | 3.46 | 0.29 | 1.83 | 76.19 | 08.53 | 06.99 | 0.65 | 1.25 | 0.09 | 0.29 | 0.07 | 0.14 | 0.17 | 5.33 |

**Table 18 (continued).**

| LOC | sample # | NMR% | C14:0 | C16:0 | C16:1 | C18:0 | C18:1 | C18:2 | C18:3 | C20:0 | C20:1 | C20:2 | C22:0 | C22:1 | C24:0 | C24:1 | FDA sats |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fairfield | 208 | 45.1 | 0.05 | 3.42 | 0.28 | 1.62 | 75.88 | 08.60 | 07.70 | 0.61 | 1.28 | 0.09 | 0.28 | 0.07 | 0.12 | 0.02 | 5.09 |
| Fairfield | 209 | 42.2 | 0.05 | 3.79 | 0.27 | 1.81 | 63.59 | 18.49 | 09.22 | 0.67 | 1.26 | 0.11 | 0.32 | 0.08 | 0.15 | 0.20 | 5.65 |
| Fairfield | 210 | 45.4 | 0.05 | 3.73 | 0.25 | 1.85 | 65.94 | 17.74 | 08.19 | 0.63 | 1.08 | 0.08 | 0.26 | 0.06 | 0.12 | 0.02 | 5.63 |
| Fairfield | 211 | 45.5 | 0.05 | 3.69 | 0.25 | 1.83 | 65.97 | 17.15 | 08.80 | 0.59 | 1.09 | 0.07 | 0.26 | 0.07 | 0.16 | 0.02 | 5.57 |
| Fairfield | 212 | 46.1 | 0.05 | 3.69 | 0.25 | 1.76 | 66.77 | 16.94 | 08.27 | 0.61 | 1.09 | 0.10 | 0.28 | 0.07 | 0.12 | 0.01 | 5.50 |
| Fairfield | 213 | 42.6 | 0.06 | 4.03 | 0.27 | 1.90 | 61.23 | 23.51 | 05.99 | 0.69 | 1.31 | 0.11 | 0.35 | 0.15 | 0.18 | 0.22 | 5.99 |
| Fairfield | 214 | 43.5 | 0.05 | 3.92 | 0.25 | 2.00 | 63.20 | 21.74 | 05.33 | 0.68 | 1.05 | 0.11 | 0.31 | 0.06 | 0.14 | 0.17 | 5.96 |
| Fairfield | 215 | 43.3 | 0.05 | 3.91 | 0.26 | 1.95 | 63.77 | 22.06 | 05.44 | 0.69 | 1.10 | 0.10 | 0.31 | 0.06 | 0.15 | 0.17 | 5.91 |
| Fairfield | 216 | 43.7 | 0.05 | 4.04 | 0.27 | 1.84 | 63.71 | 22.19 | 05.44 | 0.65 | 1.07 | 0.09 | 0.31 | 0.06 | 0.14 | 0.16 | 5.93 |
| Fairfield | 217 | 46.1 | 0.05 | 3.35 | 0.27 | 1.79 | 77.32 | 08.16 | 06.82 | 0.62 | 1.12 | 0.06 | 0.27 | 0.05 | 0.11 | 0.02 | 5.18 |
| Fairfield | 218 | 46.2 | 0.05 | 3.45 | 0.28 | 1.81 | 77.08 | 08.39 | 06.58 | 0.63 | 1.12 | 0.07 | 0.28 | 0.04 | 0.11 | 0.13 | 5.30 |
| Fairfield | 219 | 45.9 | 0.04 | 3.36 | 0.27 | 1.69 | 77.45 | 08.21 | 06.59 | 0.61 | 1.17 | 0.06 | 0.27 | 0.04 | 0.11 | 0.13 | 5.10 |
| Fairfield | 220 | 44.8 | 0.04 | 3.29 | 0.26 | 1.74 | 77.55 | 07.76 | 06.97 | 0.62 | 1.20 | 0.08 | 0.28 | 0.05 | 0.15 | 0.01 | 5.07 |
| Fairfield | 221 | 44.0 | 0.05 | 3.75 | 0.26 | 1.75 | 65.29 | 17.63 | 08.88 | 0.64 | 1.16 | 0.11 | 0.28 | 0.04 | 0.17 | 0.01 | 5.54 |
| Fairfield | 222 | 45.9 | 0.05 | 3.76 | 0.27 | 1.71 | 65.00 | 17.18 | 08.28 | 0.60 | 1.70 | 0.10 | 0.26 | 0.97 | 0.12 | 0.01 | 5.52 |
| Fairfield | 223 | 44.6 | 0.05 | 3.72 | 0.26 | 1.88 | 65.90 | 17.18 | 08.24 | 0.64 | 1.07 | 0.09 | 0.55 | 0.11 | 0.15 | 0.18 | 5.65 |
| Fairfield | 224 | 44.1 | 0.05 | 3.73 | 0.26 | 1.76 | 65.36 | 17.34 | 08.85 | 0.63 | 1.14 | 0.10 | 0.07 | 0.53 | 0.16 | 0.04 | 5.53 |
| Fairfield | 301 | 42.5 | 0.04 | 3.48 | 0.26 | 1.86 | 74.11 | 10.09 | 07.25 | 0.66 | 1.26 | 0.08 | 0.46 | 0.07 | 0.17 | 0.19 | 5.39 |
| Fairfield | 302 | 46.0 | 0.05 | 3.40 | 0.27 | 1.86 | 76.57 | 08.12 | 07.19 | 0.63 | 1.14 | 0.07 | 0.38 | 0.04 | 0.12 | 0.16 | 5.31 |
| Fairfield | 303 | 45.4 | 0.04 | 3.44 | 0.28 | 2.02 | 76.06 | 08.70 | 06.50 | 0.69 | 1.25 | 0.08 | 0.49 | 0.08 | 1.70 | 0.19 | 5.50 |
| Fairfield | 304 | 46.5 | 0.05 | 3.26 | 0.26 | 1.79 | 77.45 | 07.51 | 06.90 | 0.62 | 1.20 | 0.07 | 0.48 | 0.10 | 0.15 | 0.17 | 5.10 |
| Fairfield | 305 | 45.2 | 0.05 | 3.65 | 0.25 | 1.84 | 66.26 | 16.41 | 08.95 | 0.62 | 1.09 | 0.08 | 0.46 | 0.05 | 0.13 | 0.17 | 5.54 |
| Fairfield | 306 | 43.5 | 0.04 | 3.82 | 0.26 | 1.91 | 65.27 | 17.31 | 08.63 | 0.65 | 1.12 | 0.07 | 0.51 | 0.06 | 0.16 | 0.19 | 5.78 |
| Fairfield | 307 | 43.6 | 0.05 | 3.77 | 0.26 | 1.95 | 65.42 | 17.25 | 08.49 | 0.66 | 1.16 | 0.09 | 0.47 | 0.06 | 0.17 | 0.20 | 5.77 |
| Fairfield | 308 | 44.5 | 0.04 | 3.58 | 0.24 | 1.77 | 65.97 | 16.91 | 08.83 | 0.60 | 1.08 | 0.09 | 0.48 | 0.10 | 0.14 | 0.18 | 5.40 |
| Fairfield | 309 | 45.3 | 0.06 | 3.90 | 0.25 | 2.01 | 63.20 | 22.47 | 05.47 | 0.63 | 0.98 | 0.07 | 0.54 | 0.09 | 0.16 | 0.16 | 5.96 |
| Fairfield | 310 | 43.3 | 0.05 | 3.91 | 0.26 | 1.81 | 62.26 | 22.83 | 06.37 | 0.61 | 1.01 | 0.11 | 0.43 | 0.04 | 0.14 | 0.17 | 5.77 |
| Fairfield | 311 | 42.8 | 0.05 | 3.94 | 0.24 | 1.86 | 62.78 | 23.50 | 05.04 | 0.62 | 1.04 | 0.09 | 0.45 | 0.05 | 0.16 | 0.18 | 5.85 |
| Fairfield | 312 | 42.4 | 0.05 | 3.98 | 0.27 | 2.05 | 62.99 | 21.93 | 05.95 | 0.69 | 1.08 | 0.10 | 0.49 | 0.05 | 0.18 | 0.20 | 6.08 |
| Fairfield | 313 | 43.6 | 0.05 | 3.45 | 0.28 | 1.71 | 75.72 | 06.56 | 07.52 | 0.61 | 1.18 | 0.07 | 0.46 | 0.06 | 0.14 | 0.18 | 5.21 |
| Fairfield | 314 | 43.0 | 0.04 | 3.48 | 0.27 | 1.67 | 75.10 | 09.11 | 07.17 | 0.62 | 1.31 | 0.08 | 0.63 | 0.13 | 0.18 | 0.21 | 5.19 |
| Fairfield | 315 | 44.2 | 0.04 | 3.32 | 0.27 | 1.89 | 76.88 | 07.60 | 07.10 | 0.64 | 1.20 | 0.08 | 0.54 | 0.12 | 0.15 | 0.18 | 5.25 |

**Table 18 (continued).**

| LOC | sample # | NMR% | C14:0 | C16:0 | C16:1 | C18:0 | C18:1 | C18:2 | C18:3 | C20:0 | C20:1 | C20:2 | C22:0 | C22:1 | C24:0 | C24:1 | FDA sats |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fairfield | 316 | 44.1 | 0.05 | 3.35 | 0.28 | 1.74 | 76.02 | 08.48 | 07.39 | 0.63 | 1.30 | 0.09 | 0.33 | 0.05 | 0.13 | 0.18 | 5.13 |
| Fairfield | 317 | 41.8 | 0.05 | 3.67 | 0.27 | 1.66 | 63.70 | 17.94 | 10.03 | 0.62 | 1.22 | 0.09 | 0.36 | 0.06 | 0.13 | 0.20 | 5.40 |
| Fairfield | 318 | 43.2 | 0.05 | 3.78 | 0.27 | 1.75 | 64.37 | 18.20 | 09.07 | 0.62 | 1.13 | 0.08 | 0.34 | 0.05 | 0.12 | 0.18 | 5.58 |
| Fairfield | 319 | 44.7 | 0.05 | 3.90 | 0.28 | 1.81 | 64.67 | 18.54 | 06.27 | 0.63 | 1.10 | 0.08 | 0.04 | 0.46 | 0.14 | 0.03 | 5.76 |
| Fairfield | 320 | 43.4 | 0.05 | 4.00 | 0.27 | 1.91 | 62.75 | 22.70 | 05.63 | 0.67 | 1.09 | 0.09 | 0.40 | 0.10 | 0.17 | 0.19 | 5.97 |
| Fairfield | 321 | 41.0 | 0.05 | 4.12 | 0.27 | 1.85 | 61.78 | 24.03 | 05.16 | 0.68 | 1.15 | 0.10 | 0.39 | 0.05 | 0.17 | 0.20 | 6.02 |
| Fairfield | 322 | 42.1 | 0.05 | 4.09 | 0.29 | 1.82 | 62.28 | 23.46 | 05.27 | 0.66 | 1.10 | 0.11 | 0.41 | 0.10 | 0.17 | 0.19 | 5.97 |
| Fairfield | 323 | 45.2 | 0.05 | 3.89 | 0.26 | 1.88 | 64.13 | 21.96 | 05.47 | 0.62 | 0.99 | 0.07 | 0.39 | 0.09 | 0.15 | 0.05 | 5.83 |
| Fairfield | 324 | 43.5 | 0.05 | 3.76 | 0.25 | 1.95 | 63.75 | 21.73 | 05.86 | 0.67 | 1.12 | 0.11 | 0.38 | 0.04 | 0.15 | 0.18 | 5.76 |
| Fairfield | 401 | 42.9 | 0.05 | 3.61 | 0.26 | 1.82 | 66.26 | 16.89 | 08.52 | 0.62 | 1.10 | 0.07 | 0.41 | 0.09 | 0.13 | 0.17 | 5.48 |
| Fairfield | 402 | 43.0 | 0.05 | 3.68 | 0.27 | 1.71 | 64.95 | 16.85 | 09.02 | 0.61 | 1.68 | 0.10 | 0.32 | 0.45 | 0.12 | 0.19 | 5.43 |
| Fairfield | 403 | 42.4 | 0.05 | 3.74 | 0.28 | 1.86 | 64.96 | 17.76 | 08.52 | 0.65 | 1.19 | 0.07 | 0.46 | 0.11 | 0.16 | 0.20 | 5.65 |
| Fairfield | 404 | 42.9 | 0.05 | 3.72 | 0.27 | 1.80 | 65.29 | 17.60 | 08.61 | 0.63 | 1.12 | 0.08 | 0.42 | 0.10 | 0.13 | 0.18 | 5.57 |
| Fairfield | 405 | 43.8 | 0.05 | 3.77 | 0.26 | 1.93 | 64.40 | 21.41 | 05.59 | 0.65 | 1.06 | 0.11 | 0.38 | 0.09 | 0.14 | 0.17 | 5.74 |
| Fairfield | 406 | 45.1 | 0.05 | 3.76 | 0.25 | 2.10 | 64.60 | 21.94 | 04.97 | 0.63 | 0.95 | 0.10 | 0.34 | 0.08 | 0.11 | 0.13 | 5.90 |
| Fairfield | 407 | 42.0 | 0.05 | 3.84 | 0.27 | 2.04 | 65.21 | 20.07 | 05.77 | 0.69 | 1.13 | 0.10 | 0.40 | 0.10 | 0.16 | 0.17 | 5.94 |
| Fairfield | 408 | 43.0 | 0.05 | 3.82 | 0.27 | 2.00 | 63.68 | 21.32 | 06.10 | 0.68 | 1.12 | 0.10 | 0.41 | 0.11 | 0.17 | 0.19 | 5.87 |
| Fairfield | 409 | 43.3 | 0.04 | 3.34 | 0.26 | 1.83 | 76.62 | 08.45 | 06.67 | 0.62 | 1.31 | 0.11 | 0.35 | 0.05 | 0.14 | 0.17 | 5.20 |
| Fairfield | 410 | 46.3 | 0.04 | 3.39 | 0.29 | 1.76 | 76.30 | 08.16 | 07.41 | 0.62 | 1.22 | 0.12 | 0.05 | 0.46 | 0.15 | 0.04 | 5.19 |
| Fairfield | 411 | 43.7 | 0.05 | 3.29 | 0.28 | 1.72 | 76.97 | 07.83 | 07.24 | 0.61 | 1.28 | 0.10 | 0.31 | 0.05 | 0.12 | 0.16 | 5.05 |
| Fairfield | 412 | 44.4 | 0.04 | 3.39 | 0.29 | 1.75 | 76.62 | 08.45 | 06.91 | 0.63 | 1.25 | 0.06 | 0.34 | 0.09 | 0.12 | 0.16 | 5.19 |
| Fairfield | 413 | 43.9 | 0.04 | 3.69 | 0.27 | 1.86 | 66.13 | 17.32 | 08.05 | 0.65 | 1.18 | 0.09 | 0.37 | 0.07 | 0.13 | 0.15 | 5.59 |
| Fairfield | 414 | 42.7 | 0.04 | 3.71 | 0.26 | 1.78 | 65.14 | 17.53 | 08.86 | 0.64 | 1.17 | 0.10 | 0.41 | 0.11 | 0.11 | 0.15 | 5.54 |
| Fairfield | 415 | 41.8 | 0.04 | 3.66 | 0.27 | 1.86 | 64.55 | 17.70 | 09.02 | 0.69 | 1.27 | 0.10 | 0.44 | 0.11 | 0.13 | 0.17 | 5.56 |
| Fairfield | 416 | 44.5 | 0.05 | 3.84 | 0.28 | 1.79 | 65.78 | 17.64 | 08.03 | 0.65 | 1.11 | 0.09 | 0.40 | 0.12 | 0.11 | 0.12 | 5.68 |
| Fairfield | 417 | 42.6 | 0.05 | 3.92 | 0.26 | 2.11 | 64.14 | 21.70 | 05.27 | 0.71 | 1.07 | 0.08 | 0.35 | 0.05 | 0.14 | 0.15 | 6.08 |
| Fairfield | 418 | 42.3 | 0.05 | 3.90 | 0.28 | 1.88 | 62.66 | 23.00 | 05.48 | 0.69 | 1.15 | 0.09 | 0.40 | 0.09 | 0.15 | 0.18 | 5.83 |
| Fairfield | 419 | 43.1 | 0.05 | 3.98 | 0.27 | 1.99 | 62.91 | 23.02 | 04.96 | 0.69 | 1.10 | 0.12 | 0.44 | 0.10 | 0.17 | 0.18 | 6.02 |
| Fairfield | 420 | 44.5 | 0.05 | 3.81 | 0.26 | 1.91 | 63.70 | 22.10 | 05.54 | 0.68 | 1.10 | 0.09 | 0.40 | 0.09 | 0.13 | 0.14 | 5.77 |
| Fairfield | 421 | 43.7 | 0.07 | 4.42 | 0.11 | 3.06 | 77.01 | 06.54 | 06.13 | 0.62 | 0.86 | 0.07 | 0.66 | 0.05 | 0.23 | 0.18 | 7.55 |
| Fairfield | 422 | 45.1 |  | 3.80 | 0.18 | 2.16 | 78.26 | 07.14 | 06.29 | 0.55 | 0.91 |  | 0.41 | 0.02 | 0.15 | 0.13 | 5.96 |
| Fairfield | 423 | 43.6 | 0.07 | 4.42 | 0.10 | 2.89 | 76.73 | 06.64 | 06.39 | 0.60 | 0.90 | 0.07 | 0.65 | 0.03 | 0.30 | 0.22 | 7.38 |
| Fairfield | 424 | 46.6 |  | 3.90 | 0.14 | 2.43 | 77.50 | 07.25 | 06.50 | 0.58 | 0.87 |  | 0.47 | 0.04 | 0.16 | 0.15 | 6.33 |

**Table 18 (continued).**

| LOC | sample # | NMR% | C14:0 | C16:0 | C16:1 | C18:0 | C18:1 | C18:2 | C18:3 | C20:0 | C20:1 | C20:2 | C22:0 | C22:1 | C24:0 | C24:1 | FDA sats |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moccasin | 101 | 45.7 | 0.07 | 3.92 | 0.27 | 2.04 | 65.39 | 17.29 | 08.61 | 0.59 | 1.09 | 0.09 | 0.33 | 0.04 | 0.11 | 0.15 | 6.03 |
| Moccasin | 102 | 45.0 | 0.05 | 3.81 | 0.25 | 1.80 | 66.48 | 16.86 | 08.34 | 0.58 | 1.10 | 0.09 | 0.33 | 0.04 | 0.12 | 0.15 | 5.66 |
| Moccasin | 103 | 44.7 | 0.06 | 3.74 | 0.26 | 1.82 | 61.80 | 16.08 | 08.62 | 0.60 | 3.42 | 0.15 | 0.33 | 2.76 | 0.13 | 0.24 | 5.62 |
| Moccasin | 104 | 45.1 | 0.05 | 3.86 | 0.25 | 1.78 | 66.44 | 17.10 | 06.06 | 0.59 | 1.12 | 0.09 | 0.34 | 0.06 | 0.12 | 0.15 | 5.68 |
| Moccasin | 105 | 45.0 | 0.05 | 3.88 | 0.26 | 1.87 | 65.83 | 16.96 | 08.65 | 0.62 | 1.17 | 0.11 | 0.36 | 0.07 | 0.16 | 0.01 | 5.80 |
| Moccasin | 106 | 45.5 | 0.05 | 4.02 | 0.27 | 1.95 | 65.96 | 17.45 | 07.83 | 0.62 | 1.08 | 0.09 | 0.35 | 0.07 | 0.13 | 0.15 | 6.01 |
| Moccasin | 107 | 45.2 | 0.06 | 3.99 | 0.26 | 1.72 | 65.55 | 17.40 | 08.78 | 0.57 | 1.08 | 0.08 | 0.33 | 0.05 | 0.11 | 0.02 | 5.77 |
| Moccasin | 108 | 46.1 | 0.06 | 4.00 | 0.27 | 2.00 | 65.56 | 17.55 | 08.26 | 0.62 | 1.06 | 0.09 | 0.34 | 0.06 | 0.13 | 0.01 | 6.05 |
| Moccasin | 109 | 47.1 | 0.06 | 3.92 | 0.23 | 2.15 | 65.10 | 21.32 | 05.04 | 0.60 | 0.94 | 0.09 | 0.32 | 0.06 | 0.12 | 0.02 | 6.13 |
| Moccasin | 110 | 46.5 | 0.05 | 4.04 | 0.24 | 2.03 | 64.44 | 21.64 | 05.28 | 0.59 | 0.97 | 0.09 | 0.32 | 0.06 | 0.11 | 0.13 | 6.12 |
| Moccasin | 111 | 46.1 | 0.05 | 3.93 | 0.24 | 1.94 | 64.73 | 21.87 | 04.95 | 0.58 | 0.98 | 0.07 | 0.33 | 0.06 | 0.12 | 0.14 | 5.93 |
| Moccasin | 112 | 46.4 | 0.06 | 4.02 | 0.24 | 2.00 | 64.84 | 21.94 | 04.78 | 0.59 | 0.95 | 0.08 | 0.32 | 0.05 | 0.11 | 0.02 | 6.07 |
| Moccasin | 113 | 45.8 | 0.06 | 3.99 | 0.23 | 1.98 | 64.97 | 21.91 | 04.60 | 0.59 | 0.96 | 0.09 | 0.32 | 0.05 | 0.11 | 0.14 | 6.03 |
| Moccasin | 114 | 46.4 | 0.06 | 3.93 | 0.23 | 2.02 | 64.88 | 21.58 | 05.12 | 0.59 | 0.96 | 0.10 | 0.33 | 0.07 | 0.13 | 0.02 | 6.00 |
| Moccasin | 115 | 46.1 | 0.05 | 3.99 | 0.24 | 1.95 | 65.01 | 22.19 | 04.36 | 0.60 | 0.96 | 0.08 | 0.27 | 0.06 | 0.11 | 0.14 | 5.99 |
| Moccasin | 116 | 46.2 | 0.06 | 3.85 | 0.23 | 2.05 | 65.10 | 20.92 | 05.68 | 0.62 | 0.96 | 0.08 | 0.28 | 0.05 | 0.10 | 0.03 | 5.95 |
| Moccasin | 117 | 47.0 | 0.06 | 3.47 | 0.27 | 1.84 | 77.66 | 07.74 | 06.75 | 0.06 | 1.06 | 0.08 | 0.27 | 0.06 | 0.11 | 0.02 | 5.36 |
| Moccasin | 118 | 45.6 | 0.05 | 3.46 | 0.27 | 1.74 | 77.39 | 07.74 | 06.98 | 0.59 | 1.17 | 0.10 | 0.28 | 0.08 | 0.13 | 0.02 | 5.25 |
| Moccasin | 119 | 44.0 | 0.04 | 3.44 | 0.27 | 1.93 | 77.14 | 07.92 | 06.51 | 0.67 | 1.28 | 0.09 | 0.32 | 0.08 | 0.14 | 0.16 | 5.41 |
| Moccasin | 120 | 46.3 | 0.06 | 3.54 | 0.28 | 1.69 | 77.63 | 07.78 | 06.77 | 0.57 | 1.13 | 0.07 | 0.28 | 0.07 | 0.11 | 0.02 | 5.29 |
| Moccasin | 121 | 44.8 | 0.05 | 3.50 | 0.27 | 1.66 | 76.67 | 08.41 | 07.10 | 0.58 | 1.21 | 0.08 | 0.28 | 0.06 | 0.12 | 0.02 | 5.21 |
| Moccasin | 122 | 45.8 | 0.05 | 3.35 | 0.25 | 1.73 | 78.22 | 07.32 | 06.69 | 0.61 | 1.24 | 0.09 | 0.27 | 0.05 | 0.13 | 0.02 | 5.12 |
| Moccasin | 123 | 45.9 | 0.05 | 3.38 | 0.26 | 1.73 | 76.93 | 08.17 | 07.09 | 0.60 | 1.19 | 0.09 | 0.29 | 0.08 | 0.14 | 0.02 | 5.17 |
| Moccasin | 124 | 46.5 | 0.05 | 3.50 | 0.28 | 1.82 | 77.35 | 07.82 | 06.92 | 0.60 | 1.12 | 0.07 | 0.28 | 0.06 | 0.11 | 0.02 | 5.36 |
| Moccasin | 201 | 43.8 | 0.05 | 3.39 | 0.27 | 1.81 | 76.09 | 08.37 | 07.42 | 0.61 | 1.28 | 0.07 | 0.28 | 0.08 | 0.13 | 0.17 | 5.26 |
| Moccasin | 202 | 44.1 | 0.05 | 3.88 | 0.23 | 1.93 | 64.53 | 21.06 | 06.07 | 0.63 | 1.09 | 0.09 | 0.07 | 0.03 | 0.16 | 0.18 | 5.86 |
| Moccasin | 203 | 45.6 | 0.05 | 3.85 | 0.23 | 2.04 | 64.70 | 21.85 | 05.07 | 0.64 | 1.02 | 0.10 | 0.27 | 0.04 | 0.12 | 0.02 | 5.94 |
| Moccasin | 204 | 45.8 | 0.05 | 3.88 | 0.23 | 1.93 | 63.85 | 22.83 | 05.11 | 0.60 | 1.00 | 0.09 | 0.26 | 0.04 | 0.11 | 0.02 | 5.86 |
| Moccasin | 205 | 45.2 | 0.06 | 4.01 | 0.24 | 1.92 | 64.11 | 22.01 | 05.30 | 0.62 | 1.03 | 0.09 | 0.28 | 0.05 | 0.12 | 0.15 | 5.99 |
| Moccasin | 206 | 45.4 | 0.08 | 3.87 | 0.23 | 1.84 | 64.99 | 20.38 | 06.36 | 0.60 | 1.02 | 0.09 | 0.26 | 0.04 | 0.11 | 0.15 | 5.77 |
| Moccasin | 207 | 45.8 | 0.05 | 3.95 | 0.24 | 1.91 | 64.17 | 22.29 | 06.27 | 0.60 | 0.98 | 0.09 | 0.26 | 0.05 | 0.12 | 0.04 | 5.91 |
| Moccasin | 208 | 45.9 | 0.05 | 4.06 | 0.26 | 1.92 | 65.05 | 20.36 | 06.00 | 0.61 | 1.00 | 0.08 | 0.27 | 0.06 | 0.11 | 0.16 | 6.04 |

**Table 18 (continued).**

| LOC | sample # | NMR% | C14:0 | C16:0 | C16:1 | C18:0 | C18:1 | C18:2 | C18:3 | C20:0 | C20:1 | C20:2 | C22:0 | C22:1 | C24:0 | C24:1 | FDA sats |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moccasin | 209 | 45.0 | 0.05 | 3.40 | 0.26 | 1.74 | 77.18 | 08.06 | 06.78 | 0.61 | 1.22 | 0.08 | 0.27 | 0.06 | 0.13 | 0.17 | 5.19 |
| Moccasin | 210 | 46.2 | 0.05 | 3.55 | 0.29 | 1.78 | 76.82 | 08.52 | 06.82 | 0.58 | 1.09 | 0.05 | 0.27 | 0.05 | 0.11 | 0.02 | 5.38 |
| Moccasin | 211 | 46.6 | 0.05 | 3.59 | 0.27 | 1.86 | 76.03 | 09.66 | 06.28 | 0.60 | 1.07 | 0.05 | 0.28 | 0.04 | 0.10 | 0.13 | 5.50 |
| Moccasin | 212 | 44.7 | 0.05 | 3.85 | 0.26 | 1.84 | 63.59 | 17.00 | 08.32 | 0.60 | 2.60 | 0.11 | 0.27 | 1.39 | 0.12 | 0.01 | 5.74 |
| Moccasin | 213 | 43.1 | 0.05 | 3.84 | 0.26 | 1.78 | 65.87 | 17.32 | 08.49 | 0.60 | 1.10 | 0.09 | 0.29 | 0.05 | 0.11 | 0.15 | 5.67 |
| Moccasin | 214 | 43.4 | 0.05 | 3.92 | 0.27 | 1.82 | 65.86 | 17.39 | 08.41 | 0.61 | 1.09 | 0.09 | 0.31 | 0.05 | 0.13 | 0.01 | 5.79 |
| Moccasin | 215 | 44.8 | 0.05 | 3.90 | 0.26 | 1.78 | 67.03 | 16.53 | 08.12 | 0.60 | 1.06 | 0.08 | 0.30 | 0.04 | 0.10 | 0.14 | 5.73 |
| Moccasin | 216 | 45.9 | 0.05 | 3.52 | 0.28 | 1.79 | 76.00 | 09.20 | 06.96 | 0.60 | 1.11 | 0.07 | 0.27 | 0.04 | 0.11 | 0.02 | 5.36 |
| Moccasin | 217 | 42.4 | 0.05 | 3.94 | 0.26 | 1.89 | 65.99 | 17.37 | 07.92 | 0.66 | 1.15 | 0.09 | 0.33 | 0.04 | 0.14 | 0.17 | 5.88 |
| Moccasin | 218 | 44.1 | 0.05 | 3.96 | 0.28 | 1.90 | 65.69 | 17.68 | 08.07 | 0.65 | 1.09 | 0.12 | 0.30 | 0.05 | 0.16 | 0.01 | 5.91 |
| Moccasin | 219 | 45.1 | 0.05 | 3.76 | 0.25 | 1.79 | 65.73 | 17.27 | 08.84 | 0.61 | 1.08 | 0.09 | 0.29 | 0.04 | 0.09 | 0.13 | 5.60 |
| Moccasin | 220 | 46.1 | 0.04 | 3.47 | 0.28 | 1.76 | 76.74 | 08.44 | 06.81 | 0.57 | 1.17 | 0.07 | 0.34 | 0.05 | 0.11 | 0.15 | 5.28 |
| Moccasin | 221 | 45.7 | 0.04 | 3.50 | 0.29 | 1.87 | 77.14 | 07.98 | 06.68 | 0.60 | 1.17 | 0.07 | 0.04 | 0.42 | 0.14 | 0.07 | 5.40 |
| Moccasin | 222 | 45.6 | 0.04 | 3.50 | 0.29 | 1.76 | 76.95 | 07.88 | 07.01 | 0.57 | 1.19 | 0.06 | 0.07 | 0.49 | 0.15 | 0.05 | 5.30 |
| Moccasin | 223 | 44.5 | 0.05 | 3.83 | 0.27 | 1.86 | 65.93 | 17.04 | 08.42 | 0.58 | 1.10 | 0.07 | 0.49 | 0.09 | 0.12 | 0.16 | 5.73 |
| Moccasin | 224 | 44.4 | 0.05 | 3.88 | 0.27 | 1.95 | 66.12 | 16.88 | 08.36 | 0.60 | 1.08 | 0.07 | 0.41 | 0.05 | 0.13 | 0.17 | 5.87 |
| Moccasin | 301 | 45.9 | 0.05 | 0.34 | 0.29 | 1.89 | 77.52 | 07.46 | 06.79 | 0.60 | 1.21 | 0.06 | 0.40 | 0.05 | 0.14 | 0.17 | 5.33 |
| Moccasin | 302 | 45.4 | 0.05 | 3.33 | 0.28 | 1.79 | 76.92 | 07.78 | 07.27 | 0.57 | 1.21 | 0.06 | 0.41 | 0.05 | 0.13 | 0.16 | 5.16 |
| Moccasin | 303 | 46.0 | 0.05 | 3.38 | 0.29 | 2.06 | 77.35 | 07.57 | 06.55 | 0.64 | 1.20 | 0.06 | 0.49 | 0.06 | 0.15 | 0.17 | 5.48 |
| Moccasin | 304 | 45.0 | 0.05 | 3.42 | 0.29 | 1.81 | 77.73 | 07.50 | 06.65 | 0.57 | 1.17 | 0.06 | 0.44 | 0.05 | 0.13 | 0.15 | 5.27 |
| Moccasin | 305 | 46.5 | 0.05 | 3.45 | 0.28 | 1.80 | 77.21 | 08.21 | 06.60 | 0.57 | 1.12 | 0.06 | 0.37 | 0.05 | 0.11 | 0.14 | 5.30 |
| Moccasin | 306 | 44.5 | 0.05 | 3.59 | 0.30 | 1.84 | 76.52 | 08.33 | 06.72 | 0.58 | 1.19 | 0.06 | 0.42 | 0.09 | 0.14 | 0.17 | 5.48 |
| Moccasin | 307 | 45.8 | 0.05 | 3.50 | 0.28 | 1.86 | 77.12 | 08.08 | 06.61 | 0.59 | 1.14 | 0.06 | 0.39 | 0.05 | 0.12 | 0.16 | 5.41 |
| Moccasin | 308 | 45.9 | 0.05 | 3.56 | 0.29 | 1.86 | 76.64 | 08.04 | 06.73 | 0.58 | 1.14 | 0.06 | 0.48 | 0.09 | 0.13 | 0.17 | 5.46 |
| Moccasin | 309 | 44.7 | 0.05 | 3.92 | 0.26 | 1.90 | 66.26 | 17.13 | 08.06 | 0.59 | 1.04 | 0.07 | 0.42 | 0.04 | 0.12 | 0.15 | 5.87 |
| Moccasin | 310 | 44.1 | 0.04 | 3.88 | 0.28 | 1.85 | 66.15 | 17.34 | 08.00 | 0.61 | 1.10 | 0.08 | 0.34 | 0.05 | 0.11 | 0.17 | 5.77 |
| Moccasin | 311 | 44.3 | 0.05 | 4.10 | 0.31 | 1.76 | 65.87 | 17.44 | 08.08 | 0.59 | 1.07 | 0.08 | 0.39 | 0.07 | 0.11 | 0.16 | 5.83 |
| Moccasin | 312 | 44.0 | 0.05 | 3.93 | 0.28 | 1.84 | 65.75 | 17.44 | 08.28 | 0.61 | 1.07 | 0.07 | 0.33 | 0.05 | 0.12 | 0.19 | 5.82 |
| Moccasin | 313 | 44.8 | 0.05 | 3.77 | 0.27 | 1.72 | 66.40 | 16.56 | 08.57 | 0.58 | 1.12 | 0.11 |  | 0.58 | 0.14 | 0.13 | 5.54 |
| Moccasin | 314 | 44.1 | 0.04 | 3.70 | 0.26 | 1.75 | 65.40 | 17.38 | 08.81 | 0.60 | 1.15 | 0.08 | 0.42 | 0.09 | 0.12 | 0.19 | 5.49 |
| Moccasin | 315 | 42.9 | 0.04 | 3.88 | 0.26 | 1.87 | 62.66 | 23.01 | 05.52 | 0.61 | 1.09 | 0.11 | 0.41 | 0.09 | 0.15 | 0.20 | 5.79 |

**Table 18 (continued).**

| LOC | sample # | NMR% | C14:0 | C16:0 | C16:1 | C18:0 | C18:1 | C18:2 | C18:3 | C20:0 | C20:1 | C20:2 | C22:0 | C22:1 | C24:0 | C24:1 | FDA sats |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moccasin | 316 | 44.5 | 0.05 | 3.87 | 0.27 | 1.79 | 65.59 | 17.79 | 08.28 | 0.57 | 1.06 | 0.06 | 0.33 | 0.06 | 0.11 | 0.17 | 5.71 |
| Moccasin | 317 | 46.0 | 0.05 | 3.88 | 0.25 | 2.02 | 65.06 | 20.79 | 06.01 | 0.61 | 0.99 | 0.07 | 0.04 | 0.08 | 0.12 | 0.05 | 5.94 |
| Moccasin | 318 | 45.3 | 0.04 | 3.84 | 0.25 | 1.94 | 65.08 | 21.50 | 04.94 | 0.60 | 1.01 | 0.09 | 0.34 | 0.08 | 0.13 | 0.16 | 5.82 |
| Moccasin | 319 | 45.6 | 0.04 | 3.43 | 0.29 | 1.94 | 77.62 | 07.45 | 06.61 | 0.62 | 1.16 | 0.09 | 0.42 | 0.07 | 0.12 | 0.15 | 5.41 |
| Moccasin | 320 | 45.4 | 0.05 | 3.95 | 0.26 | 1.94 | 63.67 | 21.63 | 06.10 | 0.61 | 1.01 | 0.08 | 0.35 | 0.07 | 0.13 | 0.17 | 5.94 |
| Moccasin | 321 | 45.2 | 0.05 | 3.84 | 0.25 | 1.92 | 64.72 | 21.55 | 05.34 | 0.06 | 1.02 | 0.08 | 0.32 | 0.06 | 0.11 | 0.15 | 5.80 |
| Moccasin | 322 | 45.1 | 0.04 | 3.85 | 0.25 | 1.90 | 63.70 | 22.40 | 05.40 | 0.61 | 1.01 | 0.09 | 0.39 | 0.06 | 0.12 | 0.16 | 5.79 |
| Moccasin | 323 | 45.2 | 0.05 | 3.99 | 0.27 | 1.88 | 63.02 | 22.52 | 05.88 | 0.60 | 1.03 | 0.10 | 0.32 | 0.04 | 0.13 | 0.18 | 5.92 |
| Moccasin | 324 | 45.0 | 0.06 | 3.90 | 0.25 | 2.06 | 64.58 | 21.08 | 05.80 | 0.59 | 1.01 | 0.08 | 0.30 | 0.04 | 0.12 | 0.16 | 6.01 |
| Moccasin | 401 | 42.5 | 0.05 | 3.27 | 0.26 | 2.05 | 77.80 | 06.92 | 07.04 | 0.63 | 1.38 | 0.07 | 0.34 | 0.06 | 0.16 | 0.18 | 5.38 |
| Moccasin | 402 | 45.5 | 0.05 | 3.40 | 0.28 | 2.02 | 76.97 | 08.18 | 06.67 | 0.59 | 1.20 | 0.06 | 0.31 | 0.06 | 0.12 | 0.16 | 5.47 |
| Moccasin | 403 | 46.2 | 0.05 | 3.63 | 0.03 | 2.06 | 76.19 | 08.72 | 06.73 | 0.59 | 1.09 | 0.04 | 0.30 | 0.04 | 0.10 | 0.15 | 5.75 |
| Moccasin | 404 | 45.3 | 0.05 | 3.57 | 0.28 | 2.04 | 77.40 | 07.62 | 06.64 | 0.59 | 1.15 | 0.06 | 0.29 | 0.04 | 0.11 | 0.15 | 5.67 |
| Moccasin | 405 | 45.9 | 0.06 | 3.57 | 0.30 | 2.26 | 77.29 | 07.62 | 06.54 | 0.62 | 1.10 | 0.05 | 0.30 | 0.04 | 0.10 | 0.15 | 5.88 |
| Moccasin | 406 | 46.1 | 0.05 | 3.43 | 0.28 | 2.07 | 77.99 | 06.96 | 06.85 | 0.60 | 1.17 | 0.04 | 0.28 | 0.05 | 0.10 | 0.14 | 5.56 |
| Moccasin | 407 | 45.3 | 0.05 | 3.50 | 0.27 | 2.09 | 76.95 | 07.78 | 06.91 | 0.60 | 1.23 | 0.05 | 0.32 | 0.06 | 0.17 | | 5.64 |
| Moccasin | 408 | 46.6 | 0.06 | 3.60 | 0.30 | 2.06 | 77.03 | 07.79 | 06.87 | 0.59 | 1.13 | 0.05 | 0.27 | 0.02 | 0.10 | 0.14 | 5.72 |
| Moccasin | 409 | 45.7 | 0.06 | 3.93 | 0.25 | 2.37 | 65.66 | 19.96 | 05.55 | 0.63 | 0.99 | 0.06 | 0.28 | 0.04 | 0.11 | 0.13 | 6.36 |
| Moccasin | 410 | 45.3 | 0.06 | 3.98 | 0.26 | 2.19 | 64.86 | 20.65 | 05.87 | 0.62 | 1.05 | 0.06 | 0.30 | 0.04 | 0.12 | 0.15 | 6.22 |
| Moccasin | 411 | 45.6 | 0.06 | 3.96 | 0.25 | 2.33 | 64.99 | 21.28 | 04.92 | 0.64 | 0.99 | 0.06 | 0.28 | 0.03 | 0.10 | 0.13 | 6.35 |
| Moccasin | 412 | 45.9 | 0.06 | 3.87 | 0.25 | 2.20 | 65.02 | 20.84 | 05.47 | 0.63 | 1.02 | 0.60 | 0.32 | 0.04 | 0.11 | 0.14 | 6.12 |
| Moccasin | 413 | 45.8 | 0.06 | 3.97 | 0.25 | 2.19 | 64.50 | 21.70 | 05.15 | 0.61 | 0.97 | 0.06 | 0.29 | 0.04 | 0.11 | 0.14 | 6.21 |
| Moccasin | 414 | 45.5 | 0.06 | 4.03 | 0.26 | 2.22 | 64.18 | 20.92 | 06.09 | 0.63 | 1.01 | 0.06 | 0.32 | 0.07 | 0.17 | | 6.31 |
| Moccasin | 415 | 45.2 | 0.07 | 4.01 | 0.23 | 2.31 | 64.72 | 20.91 | 05.35 | 0.66 | 1.10 | 0.07 | 0.34 | 0.04 | 0.09 | 0.13 | 6.39 |
| Moccasin | 416 | 45.6 | 0.08 | 3.90 | 0.26 | 2.49 | 64.40 | 21.23 | 05.29 | 0.70 | 1.04 | 0.08 | 0.32 | 0.05 | 0.08 | 0.11 | 6.45 |
| Moccasin | 417 | 44.0 | 0.07 | 3.90 | 0.24 | 2.06 | 64.39 | 17.12 | 08.86 | 0.64 | 1.67 | 0.08 | 0.33 | 0.44 | 0.07 | 0.14 | 6.03 |
| Moccasin | 418 | 41.6 | 0.06 | 3.89 | 0.26 | 2.17 | 65.20 | 17.17 | 08.85 | 0.69 | 1.26 | 0.09 | | 0.39 | 0.12 | 0.04 | 6.12 |
| Moccasin | 419 | 43.9 | 0.07 | 3.89 | 0.24 | 2.05 | 64.76 | 17.62 | 08.64 | 0.64 | 1.28 | 0.08 | 0.35 | 0.17 | 0.07 | 0.14 | 6.01 |
| Moccasin | 420 | 43.9 | 0.07 | 4.02 | 0.27 | 2.16 | 64.02 | 17.36 | 08.51 | 0.66 | 2.35 | 0.08 | | 0.35 | 0.12 | 0.03 | 6.24 |
| Moccasin | 421 | 44.9 | 0.07 | 4.03 | 0.25 | 2.08 | 63.07 | 17.77 | 07.80 | 0.67 | 2.11 | 0.11 | 0.36 | 1.43 | 0.08 | 0.17 | 6.19 |
| Moccasin | 422 | 44.7 | 0.07 | 4.12 | 0.29 | 2.15 | 64.81 | 18.08 | 08.10 | 0.68 | 1.14 | 0.06 | | 0.36 | 0.10 | 0.03 | 6.34 |
| Moccasin | 423 | 44.1 | 0.07 | 3.96 | 0.25 | 2.19 | 63.96 | 17.23 | 08.63 | 0.67 | 1.83 | 0.10 | 0.35 | 0.55 | 0.07 | 0.14 | 6.22 |
| Moccasin | 424 | 46.6 | 0.06 | 3.92 | 0.27 | 2.11 | 64.44 | 18.36 | 08.35 | 0.65 | 1.14 | 0.06 | 0.36 | 0.05 | 0.08 | 0.15 | 6.10 |

**Table 18 (continued).**

| LOC | sample # | NMR% | C14:0 | C16:0 | C16:1 | C18:0 | C18:1 | C18:2 | C18:3 | C20:0 | C20:1 | C20:2 | C22:0 | C22:1 | C24:0 | C24:1 | FDA sats |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bozeman | 101 | 41.6 | 0.06 | 4.83 | 0.17 | 2.75 | 63.58 | 14.74 | 09.43 | 0.78 | 2.01 | 0.04 | 1.18 | 0.04 | .36 | 0.03 | 7.64 |
| Bozeman | 102 | 41.7 | 0.06 | 4.43 | 0.16 | 2.33 | 62.36 | 16.76 | 10.03 | 0.68 | 1.62 | 0.16 | 0.46 | 0.45 | 0.23 | 0.27 | 6.82 |
| Bozeman | 103 | 41.7 | 0.06 | 4.31 | 0.15 | 2.27 | 64.31 | 16.07 | 09.96 | 0.67 | 1.10 | 0.11 | 0.45 | 0.04 | 0.23 | 0.27 | 6.63 |
| Bozeman | 104 | 41.2 | 0.06 | 4.58 | 0.17 | 2.51 | 63.54 | 16.66 | 09.18 | 0.76 | 1.19 | 0.18 | 0.52 | 0.06 | 0.28 | 0.30 | 7.16 |
| Bozeman | 105 | 41.5 | 0.06 | 4.28 | 0.18 | 2.30 | 64.25 | 16.20 | 09.71 | 0.70 | 1.19 | 0.14 | 0.48 | 0.05 | 0.24 | 0.27 | 6.63 |
| Bozeman | 106 | 42.2 | 0.06 | 4.34 | 0.15 | 2.24 | 63.25 | 16.94 | 10.10 | 0.67 | 1.14 | 0.12 | 0.45 | 0.09 | 0.22 | 0.25 | 6.64 |
| Bozeman | 107 | 42.6 | 0.06 | 4.01 | 0.13 | 2.23 | 64.51 | 15.99 | 10.29 | 0.65 | 1.15 | 0.12 | 0.42 | 0.04 | 0.20 | 0.23 | 6.30 |
| Bozeman | 108 | 42.4 | 0.60 | 4.45 | 0.16 | 2.29 | 63.95 | 16.72 | 09.33 | 0.70 | 1.18 | 0.12 | 0.47 | 0.05 | 0.24 | 0.28 | 6.80 |
| Bozeman | 109 | 40.0 | 0.07 | 5.65 | 0.19 | 2.75 | 59.67 | 22.74 | 05.74 | 0.79 | 1.09 | 0.15 | 0.21 | 0.09 | 0.84 | 0.04 | 8.47 |
| Bozeman | 110 | 41.8 | 0.06 | 4.71 | 0.16 | 2.38 | 60.38 | 23.02 | 06.86 | 0.69 | 1.06 | 0.17 | 0.13 | 0.08 | 0.34 | 0.01 | 7.15 |
| Bozeman | 111 | 38.3 | 0.08 | 6.34 | 0.19 | 2.99 | 57.39 | 23.72 | 04.91 | 0.82 | 1.02 | 0.17 | 0.04 | 0.10 | 2.02 | 0.21 | 9.40 |
| Bozeman | 112 | 39.1 | 0.06 | 5.51 | 0.18 | 2.88 | 60.43 | 21.60 | 05.82 | 0.80 | 1.07 | 0.17 | 0.03 | 0.08 | 1.26 | 0.11 | 8.45 |
| Bozeman | 113 | 41.7 | 0.06 | 5.11 | 0.16 | 2.43 | 59.56 | 22.32 | 06.58 | 0.71 | 1.08 | 0.15 | 0.21 | 0.08 | 1.50 | 0.06 | 7.60 |
| Bozeman | 114 | 41.2 | 0.07 | 5.12 | 0.17 | 2.65 | 60.48 | 22.73 | 06.12 | 0.75 | 1.07 | 0.16 | 0.02 | 0.08 | 0.56 | 0.04 | 7.64 |
| Bozeman | 115 | 40.2 | 0.06 | 5.11 | 0.17 | 2.65 | 60.15 | 22.34 | 06.38 | 0.74 | 1.06 | 0.14 | 0.20 | 0.08 | 0.88 | 0.04 | 7.83 |
| Bozeman | 116 | 40.7 | 0.05 | 4.50 | 0.26 | 2.29 | 61.64 | 22.53 | 05.86 | 0.76 | 1.18 | 0.13 | 0.02 | 0.11 | 0.60 | 0.08 | 6.84 |
| Bozeman | 117 | 41.6 | 0.04 | 3.56 | 0.26 | 1.98 | 73.91 | 08.67 | 08.49 | 0.69 | 1.34 | 0.09 | 0.42 | 0.10 | 0.19 | 0.27 | 5.59 |
| Bozeman | 118 | 43.3 | 0.04 | 3.28 | 0.24 | 1.93 | 76.22 | 07.41 | 07.97 | 0.67 | 1.31 | 0.09 | 0.37 | 0.11 | 0.16 | 0.22 | 5.25 |
| Bozeman | 119 | 41.9 | 0.05 | 3.51 | 0.25 | 2.11 | 76.22 | 07.14 | 07.59 | 0.72 | 1.35 | 0.08 | 0.40 | 0.11 | 0.19 | 0.28 | 5.67 |
| Bozeman | 120 | 42.9 | 0.04 | 3.42 | 0.25 | 1.74 | 74.34 | 08.52 | 08.75 | 0.63 | 1.33 | 0.09 | 0.38 | 0.10 | 0.17 | 0.25 | 5.20 |
| Bozeman | 121 | 42.6 | 0.05 | 3.40 | 0.24 | 1.98 | 74.86 | 08.30 | 08.23 | 0.67 | 1.30 | 0.08 | 0.40 | 0.10 | 0.18 | 0.24 | 5.42 |
| Bozeman | 122 | 41.3 | 0.05 | 3.49 | 0.26 | 1.82 | 75.02 | 08.08 | 08.29 | 0.66 | 1.34 | 0.08 | 0.40 | 0.08 | 0.18 | 0.26 | 5.36 |
| Bozeman | 123 | 42.4 | 0.05 | 3.42 | 0.25 | 2.04 | 76.08 | 07.04 | 07.95 | 0.73 | 1.39 | 0.10 | 0.42 | 0.80 | 0.21 | 0.26 | 5.51 |
| Bozeman | 124 | 42.2 | 0.05 | 3.48 | 0.25 | 2.15 | 74.90 | 07.99 | 07.94 | 0.74 | 1.38 | 0.12 | 0.43 | 0.12 | 0.21 | 0.26 | 5.68 |
| Bozeman | 201 | 43.8 | 0.06 | 4.25 | 0.26 | 2.23 | 60.85 | 23.55 | 06.54 | 0.70 | 1.06 | 0.12 | 0.12 | 0.11 | 0.17 |  | 6.53 |
| Bozeman | 202 | 41.9 | 0.06 | 4.39 | 0.25 | 2.19 | 60.94 | 22.84 | 06.95 | 0.73 | 1.12 | 0.04 | 0.09 | 0.06 | 0.32 | 0.03 | 6.63 |
| Bozeman | 203 | 41.3 | 0.05 | 4.10 | 0.23 | 2.13 | 61.13 | 23.12 | 06.86 | 0.70 | 1.16 | 0.12 | 0.01 | 0.07 | 0.21 | 0.02 | 6.28 |
| Bozeman | 204 | 40.4 | 0.05 | 4.54 | 0.24 | 2.25 | 60.02 | 23.09 | 06.95 | 0.74 | 1.17 | 0.12 | 0.02 | 0.08 | 0.66 | 0.07 | 6.84 |
| Bozeman | 205 | 39.2 | 0.06 | 4.45 | 0.28 | 2.30 | 59.41 | 24.71 | 06.11 | 0.74 | 1.14 | 0.15 | 0.02 | 0.12 | 0.49 | 0.06 | 6.80 |
| Bozeman | 206 | 41.7 | 0.06 | 4.70 | 0.28 | 2.28 | 59.55 | 25.43 | 04.96 | 0.74 | 1.10 | 0.11 | 0.02 | 0.11 | 0.62 | 0.05 | 7.05 |
| Bozeman | 207 | 41.4 | 0.05 | 4.51 | 0.25 | 2.45 | 60.71 | 23.15 | 05.76 | 0.79 | 1.15 | 0.14 | 0.15 | 0.09 | 0.72 | 0.09 | 7.01 |
| Bozeman | 208 | 40.6 | 0.06 | 4.45 | 0.26 | 1.97 | 60.47 | 23.96 | 06.46 | 0.67 | 1.12 | 0.11 | 0.01 | 0.07 | 0.39 | 0.03 | 6.47 |

**Table 18 (continued).**

| LOC | sample # | NMR% | C14:0 | C16:0 | C16:1 | C18:0 | C18:1 | C18:2 | C18:3 | C20:0 | C20:1 | C20:2 | C22:0 | C22:1 | C24:0 | C24:1 | FDA sats |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bozeman | 209 | 41.4 | 0.04 | 3.29 | 0.22 | 2.01 | 75.56 | 07.69 | 08.02 | 0.71 | 1.41 | 0.09 | 0.42 | 0.11 | 0.20 | 0.24 | 5.35 |
| Bozeman | 210 | 41.4 | 0.04 | 3.25 | 0.23 | 1.98 | 75.88 | 07.61 | 07.82 | 0.71 | 1.39 | 0.09 | 0.44 | 0.12 | 0.20 | 0.24 | 5.26 |
| Bozeman | 211 | 42.2 | 0.05 | 3.39 | 0.26 | 1.71 | 73.45 | 09.09 | 09.09 | 0.62 | 1.37 | 0.12 | 0.38 | 0.09 | 0.14 | 0.24 | 5.14 |
| Bozeman | 212 | 43.5 | 0.05 | 3.28 | 0.25 | 1.73 | 75.05 | 08.09 | 06.91 | 0.58 | 1.23 | 0.07 | 0.36 | 0.09 | 0.12 | 0.20 | 5.05 |
| Bozeman | 213 | 42.3 | 0.04 | 3.22 | 0.24 | 1.85 | 76.19 | 07.43 | 06.12 | 0.64 | 1.32 | 0.07 | 0.40 | 0.11 | 0.16 | 0.21 | 5.11 |
| Bozeman | 214 | 42.0 | 0.05 | 3.44 | 0.27 | 1.94 | 75.12 | 07.95 | 08.24 | 0.66 | 1.31 | 0.10 | 0.41 | 0.12 | 0.17 | 0.24 | 5.42 |
| Bozeman | 215 | 42.4 | 0.04 | 3.33 | 0.27 | 1.83 | 75.36 | 08.12 | 08.10 | 0.64 | 1.32 | 0.09 | 0.41 | 0.11 | 0.16 | 0.23 | 5.20 |
| Bozeman | 216 | 40.7 | 0.05 | 3.45 | 0.26 | 1.94 | 74.96 | 08.84 | 08.87 | 0.68 | 1.31 | 0.11 | 0.08 | 0.05 | 0.20 |  | 5.44 |
| Bozeman | 217 | 40.7 | 0.05 | 3.94 | 0.26 | 2.07 | 63.90 | 17.01 | 09.72 | 0.72 | 1.24 | 0.13 | 0.44 | 0.08 | 0.18 | 0.29 | 6.05 |
| Bozeman | 218 | 40.1 | 0.05 | 3.99 | 0.27 | 1.99 | 62.51 | 17.98 | 10.31 | 0.68 | 1.18 | 0.13 | 0.42 | 0.07 | 0.16 | 0.26 | 6.03 |
| Bozeman | 219 | 41.2 | 0.05 | 3.88 | 0.26 | 2.26 | 63.72 | 16.64 | 10.04 | 0.77 | 1.24 | 0.15 | 0.46 | 0.07 | 0.19 | 0.27 | 6.19 |
| Bozeman | 220 | 41.1 | 0.05 | 3.79 | 0.26 | 2.09 | 64.20 | 17.02 | 09.64 | 0.71 | 1.21 | 0.14 | 0.43 | 0.07 | 0.18 | 0.24 | 5.92 |
| Bozeman | 221 | 42.1 | 0.04 | 3.94 | 0.21 | 1.84 | 63.25 | 17.33 | 10.65 | 0.68 | 1.19 | 0.12 | 0.39 | 0.05 | 0.13 | 0.19 | 5.82 |
| Bozeman | 222 | 40.6 | 0.04 | 3.93 | 0.20 | 1.89 | 63.92 | 17.15 | 10.07 | 0.68 | 1.19 | 0.09 | 0.54 | 0.10 | 0.19 |  | 5.87 |
| Bozeman | 223 | 42.3 | 0.05 | 3.76 | 0.20 | 1.92 | 64.94 | 16.16 | 10.26 | 0.66 | 1.15 | 0.09 | 0.41 | 0.05 | 0.17 | 0.21 | 5.72 |
| Bozeman | 224 | 40.5 | 0.05 | 4.55 | 0.22 | 2.39 | 62.67 | 17.08 | 09.57 | 0.73 | 1.45 | 0.10 | 0.43 | 0.40 | 0.36 |  | 6.99 |
| Bozeman | 301 | 41.9 | 0.04 | 3.52 | 0.18 | 2.11 | 76.49 | 07.03 | 07.63 | 0.68 | 1.30 | 0.10 | 0.43 | 0.08 | 0.20 | 0.21 | 5.68 |
| Bozeman | 302 | 41.2 | 0.04 | 3.67 | 0.20 | 1.91 | 75.72 | 07.62 | 07.77 | 0.64 | 1.30 | 0.07 | 0.54 | 0.10 | 0.20 | 0.21 | 5.62 |
| Bozeman | 303 | 41.2 | 0.05 | 3.78 | 0.20 | 1.99 | 75.07 | 07.94 | 07.92 | 0.66 | 1.30 | 0.07 | 0.57 | 0.11 | 0.35 |  | 5.82 |
| Bozeman | 304 | 42.0 | 0.05 | 3.65 | 0.18 | 1.93 | 75.41 | 07.63 | 07.84 | 0.66 | 1.45 | 0.10 | 0.51 | 0.15 | 0.19 | 0.25 | 5.62 |
| Bozeman | 305 | 41.8 | 0.05 | 3.69 | 0.19 | 2.04 | 75.33 | 07.74 | 08.13 | 0.68 | 1.28 | 0.10 | 0.48 | 0.07 | 0.25 |  | 5.77 |
| Bozeman | 306 | 41.9 | 0.04 | 3.65 | 0.18 | 1.99 | 75.96 | 07.21 | 07.65 | 0.65 | 1.29 | 0.07 | 0.57 | 0.10 | 0.19 | 0.25 | 5.68 |
| Bozeman | 307 | 42.7 | 0.05 | 3.58 | 0.19 | 1.84 | 75.16 | 08.01 | 08.08 | 0.64 | 1.27 | 0.11 | 0.59 | 0.10 | 0.18 | 0.21 | 5.46 |
| Bozeman | 308 | 41.8 | 0.05 | 3.83 | 0.18 | 1.91 | 73.89 | 09.05 | 08.08 | 0.65 | 1.31 | 0.10 | 0.52 | 0.11 | 0.33 |  | 5.78 |
| Bozeman | 309 | 41.3 | 0.06 | 4.81 | 0.19 | 2.48 | 59.93 | 22.73 | 06.12 | 0.75 | 1.10 | 0.12 | 0.64 | 0.13 | 0.90 | 0.05 | 7.34 |
| Bozeman | 310 | 40.2 | 0.06 | 4.85 | 0.20 | 2.45 | 60.82 | 21.96 | 06.06 | 0.76 | 1.13 | 0.14 | 0.68 | 0.14 | 0.70 | 0.07 | 7.36 |
| Bozeman | 311 | 41.1 | 0.06 | 4.73 | 0.21 | 2.26 | 59.31 | 23.65 | 06.62 | 0.69 | 1.06 | 0.12 | 0.66 | 0.11 | 0.48 | 0.05 | 7.05 |
| Bozeman | 312 | 39.9 | 0.05 | 4.54 | 0.31 | 2.14 | 59.25 | 24.46 | 05.78 | 0.73 | 1.12 | 0.09 | 0.50 | 0.16 | 0.78 | 0.10 | 6.72 |
| Bozeman | 313 | 39.6 | 0.05 | 4.32 | 0.29 | 2.03 | 59.72 | 23.80 | 06.65 | 0.71 | 1.15 | 0.11 | 0.53 | 0.15 | 0.44 | 0.05 | 6.40 |
| Bozeman | 314 | 38.9 | 0.04 | 4.64 | 0.32 | 2.18 | 59.34 | 23.06 | 06.78 | 0.76 | 1.17 | 0.10 | 0.74 | 0.22 | 0.58 | 0.09 | 6.86 |
| Bozeman | 315 | 41.1 | 0.05 | 4.21 | 0.26 | 2.05 | 59.16 | 24.54 | 06.48 | 0.74 | 1.20 | 0.12 | 0.57 | 0.17 | 0.38 | 0.06 | 6.31 |
| Bozeman | 316 | 39.2 | 0.05 | 4.50 | 0.29 | 2.07 | 58.77 | 24.70 | 05.95 | 0.74 | 1.18 | 0.14 | 0.61 | 0.21 | 0.70 | 0.11 | 6.62 |

**Table 18 (continued).**

| LOC | sample # | NMR% | C14:0 | C16:0 | C16:1 | C18:0 | C18:1 | C18:2 | C18:3 | C20:0 | C20:1 | C20:2 | C22:0 | C22:1 | C24:0 | C24:1 | FDA sats |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bozeman | 317 | 41.5 | 0.05 | 3.80 | 0.27 | 2.03 | 63.24 | 17.36 | 10.16 | 0.70 | 1.23 | 0.09 | 0.55 | 0.14 | 0.15 | 0.23 | 5.88 |
| Bozeman | 318 | 40.7 | 0.04 | 3.69 | 0.27 | 1.81 | 63.64 | 16.81 | 10.37 | 0.73 | 1.35 | 0.15 | | 0.83 | 0.20 | 0.12 | 5.54 |
| Bozeman | 319 | 40.2 | 0.05 | 3.84 | 0.27 | 1.76 | 61.51 | 18.43 | 11.19 | 0.68 | 1.25 | 0.11 | 0.45 | 0.13 | 0.12 | 0.22 | 5.65 |
| Bozeman | 320 | 41.0 | 0.04 | 3.59 | 0.25 | 1.91 | 63.45 | 17.15 | 10.35 | 0.74 | 1.32 | 0.15 | | 0.80 | 0.19 | 0.07 | 5.54 |
| Bozeman | 321 | 41.6 | 0.04 | 3.53 | 0.24 | 1.69 | 62.16 | 18.27 | 11.02 | 0.66 | 1.29 | 0.12 | 0.53 | 0.07 | 0.14 | 0.25 | 5.26 |
| Bozeman | 322 | 41.5 | 0.04 | 3.50 | 0.23 | 1.87 | 64.75 | 16.22 | 10.10 | 0.72 | 1.32 | 0.14 | 0.53 | 0.16 | 0.18 | 0.26 | 5.41 |
| Bozeman | 323 | 41.3 | 0.04 | 3.61 | 0.24 | 1.91 | 63.40 | 16.92 | 10.50 | 0.73 | 1.33 | 0.12 | 0.64 | 0.14 | 0.17 | 0.24 | 5.57 |
| Bozeman | 324 | 41.1 | 0.04 | 3.81 | 0.26 | 2.07 | 64.37 | 16.55 | 09.81 | 0.75 | 1.32 | 0.12 | 0.57 | 0.14 | 0.18 | | 5.92 |
| Bozeman | 401 | 40.8 | 0.05 | 4.10 | 0.28 | 1.92 | 59.76 | 23.83 | 07.13 | 0.69 | 1.17 | 0.15 | 0.54 | 0.15 | 0.22 | | 6.06 |
| Bozeman | 402 | 40.9 | 0.05 | 4.34 | 0.29 | 2.06 | 59.80 | 23.64 | 06.66 | 0.71 | 1.15 | 0.13 | 0.52 | 0.16 | 0.44 | 0.06 | 6.45 |
| Bozeman | 403 | 37.6 | 0.06 | 5.03 | 0.32 | 2.47 | 58.14 | 23.50 | 06.12 | 0.79 | 1.26 | 0.13 | 0.58 | 0.34 | 1.15 | 0.12 | 7.55 |
| Bozeman | 405 | 40.5 | 0.05 | 4.44 | 0.28 | 2.21 | 59.99 | 23.09 | 06.22 | 0.75 | 1.14 | 0.14 | 0.51 | 0.19 | 0.87 | 0.12 | 6.70 |
| Bozeman | 406 | 40.2 | 0.05 | 4.33 | 0.29 | 2.14 | 61.58 | 20.98 | 07.05 | 0.75 | 1.19 | 0.15 | 0.54 | 0.20 | 0.73 | 0.04 | 6.51 |
| Bozeman | 407 | 38.6 | 0.05 | 4.81 | 0.30 | 2.17 | 57.19 | 25.66 | 05.49 | 0.76 | 1.16 | 0.17 | 0.63 | 0.23 | 1.24 | 0.15 | 7.03 |
| Bozeman | 408 | 41.4 | 0.05 | 4.27 | 0.28 | 2.08 | 59.30 | 24.61 | 05.98 | 0.77 | 1.22 | 0.20 | 0.66 | 0.21 | 0.41 | | 6.37 |
| Bozeman | 409 | 38.9 | 0.04 | 4.01 | 0.31 | 1.87 | 62.52 | 18.40 | 09.82 | 0.71 | 1.31 | 0.12 | 0.53 | 0.15 | 0.23 | | 5.92 |
| Bozeman | 410 | 42.2 | 0.04 | 3.59 | 0.26 | 1.81 | 63.09 | 17.54 | 10.53 | 0.69 | 1.29 | 0.14 | 0.54 | 0.16 | 0.12 | 0.21 | 5.43 |
| Bozeman | 411 | 41.2 | 0.04 | 3.56 | 0.26 | 1.87 | 64.02 | 16.92 | 10.27 | 0.66 | 1.29 | 0.12 | 0.50 | 0.13 | 0.13 | 0.22 | 5.47 |
| Bozeman | 412 | 41.7 | 0.04 | 3.54 | 0.25 | 1.69 | 62.58 | 18.15 | 10.89 | 0.65 | 1.21 | 0.15 | 0.10 | 0.54 | 0.13 | 0.06 | 5.28 |
| Bozeman | 413 | 39.9 | 0.04 | 3.80 | 0.27 | 1.96 | 63.55 | 17.37 | 09.53 | 0.79 | 1.37 | 0.14 | 0.59 | 0.16 | 0.17 | 0.26 | 5.81 |
| Bozeman | 414 | 41.3 | 0.04 | 3.81 | 0.26 | 1.88 | 62.51 | 17.84 | 10.49 | 0.71 | 1.32 | 0.11 | 0.51 | 0.13 | 0.15 | 0.24 | 5.74 |
| Bozeman | 415 | 41.5 | 0.04 | 3.58 | 0.27 | 1.92 | 64.06 | 16.63 | 10.43 | 0.70 | 1.29 | 0.11 | 0.50 | 0.14 | 0.13 | 0.20 | 5.54 |
| Bozeman | 416 | 40.9 | 0.04 | 3.60 | 0.26 | 1.72 | 63.24 | 17.38 | 10.82 | 0.64 | 1.21 | 0.10 | 0.48 | 0.12 | 0.14 | 0.24 | 5.37 |
| Bozeman | 417 | 40.7 | 0.04 | 3.36 | 0.26 | 1.69 | 72.32 | 09.64 | 09.09 | 0.70 | 1.43 | 0.12 | 0.63 | 0.17 | 0.14 | 0.23 | 5.09 |
| Bozeman | 418 | 40.6 | 0.09 | 4.34 | 0.16 | 2.73 | 74.63 | 06.97 | 07.70 | 0.70 | 1.24 | 0.18 | 0.67 | 0.12 | 0.42 | 0.07 | 7.16 |
| Bozeman | 419 | 41.7 | 0.06 | 3.97 | 0.24 | 2.20 | 74.56 | 07.89 | 07.65 | 0.69 | 1.27 | 0.14 | 0.80 | 0.20 | 0.27 | 0.27 | 6.23 |
| Bozeman | 420 | 38.8 | 0.09 | 4.65 | 0.19 | 2.96 | 73.37 | 07.57 | 07.54 | 0.74 | 1.26 | 0.12 | 0.75 | 0.11 | 0.31 | 0.35 | 7.70 |
| Bozeman | 421 | 41.7 | | 3.90 | 0.21 | 2.37 | 74.77 | 07.62 | 07.83 | 0.70 | 1.29 | 0.08 | 0.67 | 0.20 | 0.37 | | 6.28 |
| Bozeman | 422 | 41.4 | 0.09 | 4.49 | 0.18 | 2.78 | 74.04 | 07.24 | 07.62 | 0.70 | 1.23 | 0.31 | 0.66 | 0.08 | 0.28 | 0.31 | 7.37 |
| Bozeman | 423 | 41.6 | | 4.11 | 0.21 | 2.15 | 73.28 | 08.50 | 08.33 | 0.64 | 1.23 | 0.09 | 0.76 | 0.22 | 0.21 | 0.29 | 6.25 |
| Bozeman | 424 | 40.4 | 0.09 | 4.58 | 0.17 | 2.83 | 74.43 | 07.41 | 07.88 | 0.69 | 1.26 | 0.11 | 0.16 | 0.06 | 0.32 | | 7.51 |

## Table 19. Soil Test Results

### Fairfield 1992

| | | | ppm | | | | | |
|---|---|---|---|---|---|---|---|---|
| Depth (in) | pH | O.M. | P | K | Na | Lime | B | Zn |
| 0-6 | 7.5 | 1.6 | 16 | 267 | 0.2 | 0 | 0.42 | 1 |
| 0-6 | 7.5 | 1.6 | 24 | 298 | 0.11 | 0 | 0.56 | 1.4 |
| 0-6 | 7.4 | 1.6 | 28 | 206 | 0.09 | 0 | 0.42 | 0.7 |
| 0-6 | 7.4 | 1.7 | 21 | 256 | 0.13 | 0 | 0.49 | 0.7 |
| 0-6 | 7.4 | 1.5 | 21 | 234 | 0.16 | 0 | 0.84 | 2.5 |
| 0-6 | 7.4 | 1.7 | 18 | 213 | 0.08 | 0 | 0.84 | 2.2 |
| 0-6 | 7.5 | 1.5 | 19 | 224 | 0.88 | 0 | 0.42 | 1.9 |
| 0-6 | 7.5 | 1.7 | 19 | 242 | 0.84 | 0 | 0.46 | 0.8 |
| mean = | 7.45 | 1.6125 | 20.75 | 242.5 | 0.31125 | 0 | 0.55625 | 1.4 |

| Depth | N | S | Cl |
|---|---|---|---|
| 0-6 | 4 | 7 | 14.24 |
| 0-6 | 5 | 10 | 21.36 |
| 0-6 | 7 | 4 | 8.9 |
| 0-6 | 4 | 5 | 10.68 |
| 0-6 | 4 | 10 | 17.8 |
| 0-6 | 5 | 13 | 7.12 |
| 0-6 | 5 | 5 | 10.68 |
| 0-6 | 7 | 8 | 12.46 |
| mean = | 5.125 | 7.75 | 12.905 |

| Depth | N | S | Cl |
|---|---|---|---|
| 6-12 | 2 | 7 | 3.56 |
| 6-12 | 2 | 8 | 3.56 |
| 6-12 | 3 | 6 | 3.56 |
| 6-12 | 2 | 4 | 3.56 |
| 6-12 | 2 | 25 | 3.56 |
| 6-12 | 2 | 8 | 3.56 |
| 6-12 | 2 | 6 | 3.56 |
| 6-12 | 3 | 4 | 3.56 |
| mean = | 2.25 | 8.5 | 3.56 |

| Depth | N | S | Cl |
|---|---|---|---|
| 12-24 | 2 | 3 | 1.78 |
| 12-24 | 2 | 14 | 1.78 |
| 12-24 | 3 | 17 | 1.78 |
| 12-24 | 2 | 4 | 1.78 |
| 12-24 | 3 | 11 | 1.78 |
| 12-24 | 2 | 6 | 1.78 |
| 12-24 | 2 | 6 | 1.78 |
| 12-24 | 2 | 10 | 1.78 |
| mean = | 2.25 | 8.875 | 1.78 |

| Depth | N | S | Cl |
|---|---|---|---|
| 24-36 | 8 | 15 | - |
| 24-36 | 8 | 13 | - |
| 24-36 | 8 | 12 | - |
| 24-36 | - | - | - |
| 24-36 | - | - | - |
| 24-36 | - | - | - |
| 24-36 | - | - | - |
| 24-36 | - | - | - |
| mean = | 8 | 13.3333 | - |

| Depth | N | S | Cl |
|---|---|---|---|
| 36-48 | 1 | 19 | - |
| 36-48 | 2 | 7 | - |
| 36-48 | 2 | 13 | - |
| 36-48 | - | - | - |
| 36-48 | - | - | - |
| 36-48 | - | - | - |
| 36-48 | - | - | - |
| 36-48 | - | - | - |
| mean = | 1.66667 | 13 | - |

## Table 19 (continued).

### Moccasin 1992

| Depth(in) | pH | O.M. | P |
|---|---|---|---|
| 0-6 | 7.7 | 2.7 | 16 |
| 0-6 | 7.7 | 2.5 | 19 |
| 0-6 | 7.5 | 2.4 | 21 |
| 0-6 | 7.3 | 2.2 | 21 |
| 0-6 | 7.4 | 2.7 | 30 |
| 0-6 | 7.5 | 2.5 | 17 |
| 0-6 | 7.4 | 2.3 | 25 |
| 0-6 | 7.2 | 2.1 | 24 |
| 0-6 | 7.2 | 2 | 15 |
| 0-6 | 7.5 | 2.4 | 17 |
| 0-6 | 7.4 | 2.4 | 18 |
| 0-6 | 7.4 | 2.7 | 21 |
| mean = | 7.43333 | 2.40833 | 20.3333 |

| | ppm | |
|---|---|---|
| Depth | N | S |
| 0-6 | 4 | 29 |
| 0-6 | 5 | 11 |
| 0-6 | 7 | 11 |
| 0-6 | 5 | 10 |
| 0-6 | 6 | 10 |
| 0-6 | 5 | 12 |
| 0-6 | 8 | 11 |
| 0-6 | 3 | 10 |
| 0-6 | 7 | 10 |
| 0-6 | 4 | 8 |
| 0-6 | 7 | 12 |
| 0-6 | 6 | 11 |
| mean = | 5.58333 | 12.0833 |

| Depth | N | S |
|---|---|---|
| 6-12 | 6 | 5 |
| 6-12 | 5 | 13 |
| 6-12 | 4 | 8 |
| 6-12 | 7 | 5 |
| 6-12 | 7 | 5 |
| 6-12 | 5 | 8 |
| 6-12 | 6 | 15 |
| 6-12 | 5 | 5 |
| 6-12 | 5 | 11 |
| 6-12 | 5 | 16 |
| 6-12 | 5 | 15 |
| 6-12 | 5 | 10 |
| mean = | 5.41667 | 8 |

| Depth | N | S |
|---|---|---|
| 12-24 | 3 | 13 |
| 12-24 | 3 | 13 |
| 12-24 | 3 | 14 |
| 12-24 | 3 | 15 |
| 12-24 | 1 | 13 |
| 12-24 | 3 | 7 |
| 12-24 | 2 | 15 |
| 12-24 | 4 | 14 |
| 12-24 | 4 | 14 |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| mean = | 2.88889 | 13.1111 |

| Depth | N | S |
|---|---|---|
| 24-48 | 1 | 19 |
| 24-48 | 1 | 19 |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| mean = | 1 | 19 |

## Table 19 (continued).

### Bozeman 1992

| | | | ppm | | | |
|---|---|---|---|---|---|---|
| Depth (in) | pH | O.M. | P | K | Na | Zn |
| 0-6 | 7.2 | 2.8 | 23 | 304 | 0.07 | - |
| 0-6 | 7.4 | 3.2 | 26 | 317 | 0.08 | - |
| 0-6 | 7.4 | 3.3 | 17 | 260 | 0.07 | - |
| 0-6 | 7.6 | 2.9 | 19 | 315 | 0.06 | - |
| 0-6 | 7.7 | 3.1 | 18 | 320 | 0.08 | - |
| 0-6 | 7.6 | 2.7 | 23 | 315 | 0.07 | - |
| 0-6 | 7.7 | 3.2 | 20 | 312 | 0.08 | - |
| 0-6 | 7.7 | 3 | 20 | 311 | 0.07 | - |
| 0-6 | 7.9 | 3.1 | 19 | 349 | 0.09 | - |
| 0-6 | 7.7 | 3.1 | 23 | 354 | 0.07 | - |
| mean = | 7.59 | 3.04 | 20.8 | 315.7 | 0.074 | |

| Depth | N | S |
|---|---|---|
| 0-6 | 8 | 20 |
| 0-6 | 15 | 9 |
| 0-6 | 9 | 3 |
| 0-6 | 5 | 8 |
| 0-6 | 9 | 5 |
| 0-6 | 3 | 4 |
| 0-6 | 8 | 7 |
| 0-6 | 7 | 5 |
| 0-6 | 5 | 5 |
| 0-6 | 4 | 5 |
| 0-6 | | |
| 0-6 | | |
| mean = | 7.3 | 7.1 |

| Depth | N | S |
|---|---|---|
| 6-12 | 7 | 3 |
| 6-12 | 13 | 3 |
| 6-12 | 7 | 5 |
| 6-12 | 4 | 4 |
| 6-12 | 5 | 5 |
| 6-12 | 3 | 5 |
| 6-12 | 5 | 5 |
| 6-12 | 5 | 5 |
| 6-12 | 3 | 4 |
| 6-12 | 3 | 5 |
| 6-12 | | |
| 6-12 | | |
| mean = | 5.5 | 4.4 |

| Depth | N | S |
|---|---|---|
| 12-24 | 7 | 3 |
| 12-24 | 3 | 3 |
| 12-24 | 3 | 3 |
| 12-24 | 3 | 3 |
| 12-24 | 3 | 4 |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| mean = | 3.8 | 3.2 |

| Depth | N | S |
|---|---|---|
| 24-48 | 2 | 11 |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| mean = | 2 | 11 |

## Table 19 (continued).

### Fairfield 1993

| | | | ppm | | | | | ppm | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Depth (in) | pH | O.M. | P | K | Zn | Depth | N | S | NH4 | CL- |
| 0-6 | 7.7 | 2.1 | 17 | 350 | 0.9 | 0-6 | 10 | 23 | 10.1 | 10.7 |
| 0-6 | 8.1 | 1.3 | 21 | 407 | 0.5 | 0-6 | 5 | 15 | 10.7 | 12.5 |
| 0-6 | 7.9 | 3.3 | 42 | 529 | 0.5 | 0-6 | 5 | 6 | 11.2 | 7.12 |
| 0-6 | | | | | | 0-6 | 4 | 10 | 9.1 | 5.34 |
| 0-6 | | | | | | 0-6 | 5 | 14 | 9.6 | 7.12 |
| 0-6 | | | | | | 0-6 | 5 | 10 | 10.7 | 7.12 |
| 0-6 | | | | | | 0-6 | 5 | 25 | 13.3 | 7.12 |
| 0-6 | | | | | | 0-6 | 3 | 24 | 10.1 | 5.34 |
| 0-6 | | | | | | 0-6 | | | | |
| 0-6 | | | | | | 0-6 | | | | |
| 0-6 | | | | | | 0-6 | | | | |
| 0-6 | | | | | | 0-6 | | | | |
| mean = | 7.9 | 2.23 | 26.7 | 429 | 0.63 | mean = | 5.25 | 15.9 | 10.6 | 7.79 |

| Depth | N | S | NH4 | CL- |
|---|---|---|---|---|
| 6-12 | 10 | 23 | 10.1 | 10.7 |
| 6-12 | 5 | 15 | 10.7 | 12.5 |
| 6-12 | 5 | 6 | 11.2 | 7.12 |
| 6-12 | 4 | 10 | 9.1 | 5.34 |
| 6-12 | 5 | 14 | 9.6 | 7.12 |
| 6-12 | 5 | 10 | 10.7 | 7.12 |
| 6-12 | 5 | 25 | 13.3 | 7.12 |
| 6-12 | 3 | 24 | 10.1 | 5.34 |
| 6-12 | | | | |
| 6-12 | | | | |
| 6-12 | | | | |
| 6-12 | | | | |
| mean = | 5.25 | 15.9 | 10.6 | 7.79 |

| Depth | N | S | NH4 | CL- |
|---|---|---|---|---|
| 12-24 | 5 | 22 | 9.5 | 17.8 |
| 12-24 | 4 | 20 | 5.2 | 19.6 |
| 12-24 | 4 | 8 | 5.9 | 7.12 |
| 12-24 | 9 | 27 | 6.9 | 19.6 |
| 12-24 | 3 | 35 | 7.5 | 10.7 |
| 12-24 | 5 | 13 | 5.3 | 14.2 |
| 12-24 | 5 | 38 | 8 | 10.7 |
| 12-24 | 1 | 26 | 9.1 | 3.56 |
| 12-24 | | | | |
| 12-24 | | | | |
| 12-24 | | | | |
| 12-24 | | | | |
| mean = | 4.5 | 23.6 | 7.18 | 12.9 |

| Depth | N | S | NH4 | CL- |
|---|---|---|---|---|
| 24-36 | 1 | 17 | 6.4 | 7.12 |
| 24-36 | 5 | 28 | 7.5 | 12.5 |
| 24-36 | 2 | 38 | 5.3 | 8.9 |
| 24-36 | 3 | 27 | 5.9 | 16 |
| 24-36 | | | | |
| 24-36 | | | | |
| 24-36 | | | | |
| 24-36 | | | | |
| 24-36 | | | | |
| 24-36 | | | | |
| 24-36 | | | | |
| 24-36 | | | | |
| mean = | 2.75 | 27.5 | 6.28 | 11.1 |

| Depth | N | S | NH4 | CL- |
|---|---|---|---|---|
| 36-48 | 3 | 24 | 5.9 | 7.12 |
| 36-48 | | | | |
| 36-48 | | | | |
| 36-48 | | | | |
| 36-48 | | | | |
| 36-48 | | | | |
| 36-48 | | | | |
| 36-48 | | | | |
| 36-48 | | | | |
| 36-48 | | | | |
| 36-48 | | | | |
| 36-48 | | | | |
| mean = | 3 | 24 | 5.9 | 7.12 |

## Table 19 (continued).

### Moccasin 1993

| | | | ppm | | | |
|---|---|---|---|---|---|---|
| Depth (in) | pH | O.M. | P | K | Na | Zn |
| 0-6 | 7.2 | 3.07 | 25.3 | 26.8 | - | - |
| 0-6 | 7.3 | 3.2 | 20.7 | | | |
| 0-6 | 7.2 | 3.4 | 28.1 | | | |
| 0-6 | | | | | | |
| 0-6 | | | | | | |
| 0-6 | | | | | | |
| 0-6 | | | | | | |
| 0-6 | | | | | | |
| 0-6 | | | | | | |
| 0-6 | | | | | | |
| 0-6 | | | | | | |
| 0-6 | | | | | | |
| mean = | 7.23333 | 3.22333 | 24.7 | 26.8 | - | - |

| Depth | N | S |
|---|---|---|
| 0-6 | 5.9 | 5 |
| 0-6 | | |
| 0-6 | | |
| 0-6 | | |
| 0-6 | | |
| 0-6 | | |
| 0-6 | | |
| 0-6 | | |
| 0-6 | | |
| 0-6 | | |
| 0-6 | | |
| mean = | 5.9 | 5 |

| Depth | N | S |
|---|---|---|
| 6-12 | 6 | 5 |
| 6-12 | | 10 |
| 6-12 | | 8 |
| 6-12 | | 5 |
| 6-12 | | 5 |
| 6-12 | | 8 |
| 6-12 | | 12 |
| 6-12 | | 5 |
| 6-12 | | 11 |
| 6-12 | | 16 |
| 6-12 | | 11 |
| 6-12 | | 10 |
| mean = | 6 | 7.25 |

| Depth | N | S |
|---|---|---|
| 12-24 | 7.5 | 10 |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| mean = | 7.5 | 10 |

| Depth | N | S |
|---|---|---|
| 24-48 | 1 | 12 |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| mean = | 1 | 12 |

## Table 19 (continued).

### Bozeman 1993

| Depth (in) | pH | O.M. | P | K | Na |
|---|---|---|---|---|---|
| 0-48 | 7 | 1.5 | 9 | 322 | 0.09 |
| 0-48 | 6.8 | 1.7 | 10 | 377 | 0.07 |
| 0-48 | 6.8 | 1.4 | 11 | 343 | 0.06 |
| 0-48 | 6.9 | 1.5 | 12 | 331 | 0.07 |
| 0-48 | 7.6 | 3.1 | 18 | 299 | 0.06 |
| 0-48 | 7.5 | 3.3 | 28 | 329 | 0.05 |
| 0-48 | 7.7 | 2.8 | 29 | 316 | 0.05 |
| 0-48 | 7.5 | 2.9 | 27 | 346 | 0.05 |
| 0-48 | | | | | |
| 0-48 | | | | | |
| 0-48 | | | | | |
| 0-48 | | | | | |
| mean = | 7.225 | 2.275 | 18 | 332.875 | 0.0625 |

| Depth | N | S |
|---|---|---|
| 0-6 | 2 | 14 |
| 0-6 | 3 | 3 |
| 0-6 | 2 | 4 |
| 0-6 | 3 | 10 |
| 0-6 | 9 | 9 |
| 0-6 | 8 | 8 |
| 0-6 | 9 | 7 |
| 0-6 | 9 | 6 |
| 0-6 | | |
| 0-6 | | |
| 0-6 | | |
| 0-6 | | |
| mean = | 5.625 | 7.625 |

| Depth | N | S |
|---|---|---|
| 6-12 | 2 | 3 |
| 6-12 | 3 | 6 |
| 6-12 | 3 | 6 |
| 6-12 | 3 | 11 |
| 6-12 | 11 | 5 |
| 6-12 | 9 | 5 |
| 6-12 | 20 | 5 |
| 6-12 | 18 | 5 |
| 6-12 | | |
| 6-12 | | |
| 6-12 | | |
| 6-12 | | |
| mean = | 8.625 | 5.75 |

| Depth | N | S |
|---|---|---|
| 12-24 | 2 | 3 |
| 12-24 | 3 | 6 |
| 12-24 | 3 | 6 |
| 12-24 | 3 | 11 |
| 12-24 | 11 | 5 |
| 12-24 | 9 | 5 |
| 12-24 | 20 | 5 |
| 12-24 | 18 | 5 |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| 12-24 | | |
| mean = | 8.625 | 5.75 |

| Depth | N | S |
|---|---|---|
| 24-48 | 30 | - |
| 24-48 | 11 | |
| 24-48 | 20 | |
| 24-48 | 27 | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| 24-48 | | |
| mean = | 22 | |

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