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Research report submitted to the Organic Farming Research Foundation:

Project Title:

Effects of organic alternatives for weed control and ground cover management on tree fruit growth, development and productivity

FINAL PROJECT REPORT

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Silver Spruce Orchard, Hotchkiss, Colorado
Western Colorado Research Center – Rogers Mesa, Hotchkiss, CO.

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Introduction

Organic fruit production in the US, especially the western regions, is expanding. The increase is occurring for both economic and ecological reasons. Current market conditions dictate that organic apple growers produce large, flavorful, high quality fruit. Large, high quality fruit receive price premiums and market acceptance whereas small fruit can be difficult to sell, even at lower prices. To grow large fruit, trees must be unstressed and provided with adequate water and nutrition. Weeds can compete with fruit trees for both water and nutrients. Research has demonstrated that weed competition in young fruit trees reduces tree growth and efficiency, and therefore decreases fruit production and fruit size (Merwin and Stiles, 1994). Reduced tree growth reduces tree volume and potential production. Thus, it is a standard orchard practice to control weeds during the establishment and early growth of an orchard. However, the effect of weed competition on production and fruit size of mature fruit trees has not been studied. Most experiments are conducted on young trees so that blocks can be established solely for the purpose of the experiment. Most commercial fruit, both peaches and apples, is produced on mature trees. Thus it is important to understand the effects or lack of effects that weeds may have on a mature tree. This information could have significant impact on how orchards are managed.

Currently, organic growers spend considerable time and money controlling or removing weeds from their orchards based primarily on the research trials in young orchards. If weeds have only a minor effect on fruit size in mature trees, this time and money could be redirected to other parts of the operation. If weeds do have an effect, then the grower needs to know if one means of weed control is more effective than another. This study investigated the effects of several different weed control methods on fruit yield size in mature apple trees. The information generated will give organic growers better knowledge on how to manage weeds while producing large, marketable fruit.

This research was conducted at two different orchards in the North Fork Valley of the Gunnison River in western Colorado. The orchards are within two miles of each other on similar soils, however, the RM site is lower in elevation and therefore subject to lower springtime temperatures.

Materials and Methods

This research was conducted at two sites near Hotchkiss, Colorado, approximately one mile apart. Site one was a commercial, certified organic block of nine-year old Gala apples on EMLA 26 rootstock at Silver Spruce Orchards (SSO), on an Aqua Fria clay loam soil. The second site is an eight-year old Golden Delicious orchard on EMLA 26 rootstock, on a Mesa clay loam soil, at the Colorado State University Rogers Mesa Research Center (RM). Both blocks used for this study have eight rows, of which the middle six rows were used for the data collection. The experimental design is a randomized complete block with six treatments and eight replications. Plots consisted of five consecutive trees where treatments were applied. Within each plot, the 3 center trees were used for data collection with the 2 outside trees in each plot serving as guard trees. The six different treatments were applied in the tree row. The tree row consisted of a six-foot wide strip, three feet on either side of the tree trunk. The six different weed control treatments were: 1) a mowed control (M), (2) flamer (F), 3) landscape fabric (LF), 4) shredded paper mulch (P), 5) mowing with material thrown into the tree row (M&T), and 6) shredded bark mulch (B). A seventh treatment was added at the SSO site only, called farmer's favorite (FF), where no weed treatments were imposed and weeds were allowed to grow throughout the season. The experimental plots were established during the summer of 2000 with data collection from 2001 through 2003. A permanent weather station is located at RM and data is downloaded to a computer daily. A summary of average in-season climatic data can be found in Table 1, and monthly weather summaries are located in Appendix 1. For evaluation purposes of weather data, the growing season was defined as April 1st to August 31st. All three years of the study were considered drought years due to below average in-season precipitation (Table 1) and below average annual precipitation (Appendix A). However, of the three drought years 2002 was considered a severe drought year not only because of the very low precipitation amounts but also because of the extreme dryness and the extreme heat (Table 1). Average in-season precipitation at RM over the last 20 years is 4.85 inches and average maximum high temperature is approximately 80˚F (Table 1). In-season precipitation for both 2002 and 2003 was ½ inch or less and average maximum temperatures were above 85˚F and 83˚F, respectively.

Table 1. Average in-season climatic data 2001-2003.

Year	MaxTemp (˚F)	Min Temp (˚F)	Vapor Pres. (mb)	Precip. (in)	Min RH (%)	GDD	Ref ET (in)
2001	82.7	49.7	9.4	1.1	20.2	1180	38.4
2002	85.4	49.6	7.5	0.4	13.9	1270	40.6
2003	83.4	49.6	8.9	0.5	17.4	1148	37.4
20 yr avg	79.8	48.2		4.85			28.0

Organic fertilizer was applied each spring at the rate of 25 lbs of nitrogen (N) ac^{-1}. What remained of the mulches in the second and third springs was raked aside prior to fertilizer application. Following spring fertilizer application the old mulch was then raked back into the tree row over the organic fertilizer and new mulches applied. Mulches were renewed or replenished each spring in the tree row to a depth of approximately eight inches. The P mulch consisted of shredded paper recycled from a local bank. The B mulch consisted of coarse bark from a local lumber mill. For the landscape fabric treatment, the fabric was removed, fertilizer applied, and the fabric replaced. The flamer and both mowing treatments were applied approximately every two weeks to one month as needed during the growing season.

Trees were pruned each winter. Approximately two weeks after bloom, fruit were thinned to an equivalent number of fruit per tree to establish a consistent crop load across all treatments. The orchards were micro-sprinkler irrigated approximately every five to ten days as needed during the growing season.

Data were collected for weed density, fruit yield and quality, tree growth and soil N and organic matter (OM) levels. Leaf samples were taken in the second week of August each year for nutrient analysis. Weed density, or the percentage of the tree row covered by weeds, was estimated on all plots approximately once a month during the growing season, May through August, prior to flame and mowing treatments. The weed density was then averaged over the growing season for each treatment. Counting and weighing the fruit from each of the three data trees within each plot at harvest determined fruit yield and quality. Average fruit size was calculated from total fruit weight and fruit number, as a measure of fruit size. Tree growth was determined by measuring the circumference of each of the three data trees in each plot and calculating the total trunk cross-sectional area (TCSA) at six inches above ground level. Tree growth measurements were taken prior to the initiation of the study and following the onset of dormancy each fall. Tree growth was evaluated as a percentage increase in tree TCA between the initial measurement and final measurement following the 2003 harvest. Soil samples were taken prior to bud break and following the first fall frost each year. The soil was analyzed for nitrate-N (NO_3-N), ammonium-N (NH_4-N) and percent organic matter (OM). All data were initially analyzed combining both sites. It was found that including site in the analysis showed a significant interaction between the two sites in all data; therefore, all data was subsequently analyzed individually by site. Data was analyzed using the general linear model with a probability level of 0.05 (SAS Institute, 2001).

Results & Discussion

Weed Density

Weed density data show a significant treatment by year interaction for both sites; therefore, data were analyzed separately for each year at each site. For SSO, weed density was significantly higher in the first year, 2001, than either the second or third year. The decrease in weed density over the three years may indicate a cumulative treatment effect over time as a result of the three years of treatments (Table 2). Weed density at RM started much lower than at SSO and remained lower throughout the three years of the study.

Table 2. Weed density 2001-2003.

Site	Silver Spruce Orchard	Rogers Mesa
YEAR	---------------------------weed density (%)-----------------------	
2001	73a*	44a
2002	42b	26c
2003	37c	35b

* Different letter indicates significant differences between means within a column. ($P < 0.05$).

At the SSO in 2001 the mowed (M), farmer's favorite (FF) and mow & throw (M&T) treatments had a significantly higher weed density than the other treatments, with the landscape fabric (LF) having significantly lower weed density than the other treatments, as expected (Figure 1). In 2002, the M and FF were significantly higher and the LF significantly lower in weed density than the other treatments (Figure 1). In 2003, the FF treatment was significantly higher than all other treatments and the LF had significantly lower weed density. In all treatments except FF, weed density was less each subsequent year, probably due to the cumulative effect of the treatments over the three years of the study. The weed density in the FF treatment was much less in 2002 than in the other two years, presumably due to the severe drought. Although irrigation was done on a regular basis, the extremely low relative humidity and very high daytime temperatures may have contributed to the reduced weed density (Table 1 and Appendix A).

At RM in 2001, the M and M&T treatments had significantly higher weed density than the other treatments and the LF had significantly less weed density (Figure 2). In 2002, the M, flamed (F) and M&T had significantly more weed density than the other treatments with the LF treatment the least. In 2003, only the M treatment had significantly higher weed density and again the LF treatment had the least. Except for the M treatment, all treatments did show some reduction in weed density from year one to year three of the study, as was the case at SSO. In 2002, the drought year had marked reductions in weeds in most treatments (Figure 2).

Overall the LF, paper mulch (P) and bark mulch (B) treatments appear to have shown the best weed suppression at both sites. Although at the SSO site the M, F and M&T treatments show definite improvement from first to third years of the study, this is not the case at the RM site that had less weed pressure in general than the SSO site (Figures 1 and 2). The lower weed pressure at the RM site is probably due to less overall fertility than the SSO site (discussed below).

Fruit Yield

Fruit yields varied significantly by year at both sites. This is probably due to several factors: differences in soil fertility and weed pressure, extent of irrigation water availability and differences in general tree health and vigor. The higher soil fertility at SSO (discussed below) is indicated by higher yields and greater weed pressure. The extent of irrigation water availability also played a significant role, particularly in 2002. There were marketable fruit yields in all three years at the SSO site. The SSO site has late season irrigation water available from a secondary source not available at the RM site. At the RM site there was no harvest in 2001 due to late spring frosts and no marketable fruit yield in 2002 due to a complete absence of irrigation water in the last two months of cropping because of the severe drought. The orchard at the Silver Spruce site exhibits greater tree health and vigor than the orchard at the RM site. This may be due to different apple varieties: the Gala apples at SSO may do better in general in our climate than the Golden Delicious apples at RM. Also, poorer soil fertility over the long-term reduces overall health, vigor and productivity of an orchard, which is evident at RM. Given these parameters each site will be examined individually for yield and quality.

At SSO, yields varied widely by year and treatment (Figure 3). In 2001, the P treatment yielded more than all other treatments but not significantly higher than the M, F or B treatments. This is probably due to the study being in its first year so the treatment effects have not had sufficient time to take full effect and show significant treatment differences (Figure 3). This may be especially true in organic systems and perennial tree crops versus the typically quicker response of annual crops and/or conventional cropping systems where conventional fertilizers are readily available for plant uptake. In 2002, there were no significant yield differences in any of the treatments applied at SSO (Figure 3). This is probably due to heat stress. The relative humidity (RH) was very low and temperatures were very high during the growing season in 2002 and probably had major effect on yield (Table 1). In 2003, the P treatment yielded significantly higher than all other treatments (Figure 3).

At RM, there was no marketable fruit yield in the first two years of this study. In 2003, the LF treatment yielded significantly higher than all other treatments (Figure 4). This may be due to no weed competition in the LF treatment but this result does not hold at the SSO in any of the three years (Figure 3). The two mulch treatments, the P and B, and the F treatment, did yield higher than the mowing treatments of M, and M&T, but not significantly higher (Figure 4).

The yield results indicate that some form of ground cover or mulching for weed control can significantly increase fruit yields in these mature orchard blocks, although the results are not as unambiguous as we would like.

Fruit Size

For this study we will define fruit size as the average fruit weight, assuming that the fruit densities were not different due to treatment. Therefore, for our purposes, we will use fruit weight as an indicator of fruit size.

The data for SSO indicate that there was no significant treatment by year interaction and that only year showed any significant differences. Therefore, treatments were averaged over years. This data shows that no treatment produced significantly higher fruit size than any other treatment over the three years of the study. The data did show that fruit size was significantly different each year. The highest fruit size was in 2001 and the least in the severe drought year of 2002. Presumably, the climate and growing conditions in each particular year had a more significant effect on fruit size than any of the treatments imposed (Table 3).

Table 3. Fruit size 2001-03, Silver Spruce Orchard.

Year	Average Fruit Weight (g)
2001	154a*
2002	117c
2003	126b

* Different letter indicates significant differences between means ($P < 0.05$).

The data for RM for 2003, the one year there was fruit yield, shows no significant difference in fruit weight between any treatments. The fruit weights ranged from 99 g for the B treatment to 87 g for the M treatment (data not presented).

Tree Growth

Tree growth showed no significant treatment differences at either the SSO site, or at the RM site (Figure 5 & 6). Although the growth at RM is higher than at SSO, the larger growth was not reflected in higher yields than at SSO. The fact that the tree growth was a larger percentage of initial tree size at RM may be due to the trees not having produced a crop the first two years of the study and the trees partitioning the energy to growth in the absence of fruit production. There does appear to be a correlation between tree growth and yield when looking at the sites individually. That is that at SSO, the treatment with the highest yield was the P treatment, which is also the treatment with the most tree growth (Figure 3 and Figure 5). The same is also true at the RM site; the LF treatment had the highest yield and also the most tree growth (Figure 4 and Figure 6).

Soil Organic Matter

The soil organic matter (OM) showed a significant increase at both SSO and the RM site based on the percent change over the three years of the study (Table 4). The percent increase was larger at RM than at SSO probably due to the fact that the OM levels at the start of the study were higher at SSO than at RM. The percent (%) OM at SSO at the beginning of the study in the spring of 2001 was 2.3%, and the %OM at RM was 1.1%.

Table 4. Organic matter percent increase 2001 – 2003.

Site	Silver Spruce Orchard	Rogers Mesa
Treatment	--------- Organic matter increase (%) -------	
Mow	77.8 bc*	114.1 a
Flamer	61.1 cd	94.0 ab
Landscape Fabric	28.8 d	64.2 b
Paper	47.5 cd	101.6 ab
Farmers' Favorite	25.2 d	N/A
Mow & Throw	94.1 ab	112.8 a
Bark	119.3 a	96.7 ab

* Different letter indicates significant differences between means within a column ($P < 0.05$).

At the SSO site, the largest %OM increase occurred in the B treatment and was significantly higher than all other treatments except the M&T treatment. The results indicate that any of these treatments will increase OM levels in the short-term, likely due to yearly additions of organic fertilizer. These results are somewhat as expected, in that the LF and FF treatments have the lowest increase, probably due to lack of weeds and not mowing, respectively.
The %OM increase at the RM site showed significant differences between the M and M&T treatments, the highest %OM increase, and the LF treatment, the lowest %OM increase. As with SSO, the LF treatment resulted in the lowest increase.

Leaf Nutrient Content

Leaf nutrient analyses were conducted for the following nine nutrients: N, P, K, S, Ca, B, Zn, Mn and Fe. There were no significant differences in any of the nine leaf nutrients in the analysis over the three years of the study (Figures 7-24). The lack of significant differences may be due to similarity in fertility regime over the course of the study.

Soil Inorganic Nitrogen

Soils were sampled for NO_3-N and NH_4-N prior to the start of the study and in the fall each year. However, the source of organic fertilizer was changed between the first and second years due to fertilizer availability. There were no significant effects on soil inorganic N due to treatments for the course of the study. There were, however, significant year-to-year differences of soil inorganic N over the three years of the study.

The soil NO_3-N at SSO remained relatively steady until the fall of 2003 when it did increase significantly (Figure 25). The reason for this increase is not known at this time. At the

Rogers Mesa site there were no significant differences in soil NO_3-N levels over the course of the study (Figure 26). The NO_3-N did increase between the start of the study and the fall of the first year and remained at the same level until the end of the study. This is possibly due to an adequate N application rate and the trees not needing to 'draw down' the soil N for tree growth and maintenance.

The soil NH_4-N levels at both sites did have significant year-to-year differences; however, the actual difference are small, between two and six lbs NH_4-N per acre (Figures 27 & 28). Typically, soil NH_4-N levels do not show large fluctuations, as can be the case for soil NO_3-N levels. This is due to large microorganism populations under organic systems that quickly immobilize the NH_4-N as it is mineralized from decomposing soil organic matter.

Soil Microbiology

No significant differences in soil organisms were found between treatments at either site over the three years of the study. This was surprising given the broad diversity of the treatments. However, the amount of organic matter available in all treatments may have masked any treatment effects.

Conclusions

Within the confines of this study, different weed treatments do not affect fruit size and for the most part do not affect fruit yield. Two of the treatments may show a trend toward higher yields (P at SSO and LF at Rogers Mesa), but these were not significant. If this study were extended, it would be of interest to see if these differences in yield became significant.

This study does show that mulching reduces weed density, and hence, weed pressure on the orchard. The correlation of reduced weed density to any yield changes was weak at best. For example, at SSO the P, B and F treatments had similar weed densities, but only the P treatment had a higher yield. Therefore, there does not seem to be a direct correlation between weed density and yield or fruit size. At Rogers Mesa, the lowest weed density did have increased yield in 2003, but there was no apparent correlation with any other treatment.

Leaf nutrient status was not significantly affected by any of the treatments imposed at either site. Leaf N was adequate across all treatments, even with relatively modest N applications. Thus, despite changes in weed density and pressure, weeds are not affecting leaf N. This would indicate that weeds are not effectively competing with the trees for N, at least within the confines of this study.

Soil organic matter levels were significantly increased over the three years of the study in most treatments, the benefits of which may be a higher quality organic soil system in the years to come. This does not appear to have an immediate, short-term impact on fruit yield or size. It appears that soil inorganic N was positively influenced during the study; however, this may be much more heavily influenced by increases in OM levels than by imposed treatments. Again, the increase in soil N did not affect leaf N.

Tree growth, as measured by TCSA, was also unaffected by the significant differences in weed densities throughout the study. There was no correlation between tree growth and weed density or fruit yield. In fruit trees, it would be normal to expect that the highest yielding trees might have the lowest tree growth since fruit and growth are often negatively correlated. In fact, the best way to slow a vigorous tree is to encourage heavy fruiting. However, in this study the few treatments with significant increases in yield had similar tree growth rates to the other treatments, again indicating that the nutritional needs of the trees were adequately fulfilled, despite differences in weed densities.

The bottom line to a fruit grower in making any production decision is the effect of the decision on fruit yield and size. Fruit yield and size ultimately control the economics of the operation. A production practice that costs money, but increases yield and/or size may be worthwhile, depending on the cost and increases in yield. However, a practice that has no effect on fruit yield or size might be considered wasteful, or at best, optional. In this three-year study of different organic weed control methods, there was very little indication that weed densities in mature, bearing apple trees have an effect on yield or size.

The effects of those weeds on nutrient cycling was not studied, but with an overall increase and differences in soil organic matter by treatment, it might be expected that soil dynamics might be different between treatments over time. This difference, however, may not be apparent in the trees or their fruit yields. Fruit trees are a highly buffered system. The trees are resistant to anything but small incremental changes over a period of time, thus making it difficult to detect differences due to treatments. On the other hand, even with different soils and systems, trees are often able to extract the nutrients they need. If anything this study brings up the question of how and when trees take in nutrients and how different nutrient cycling scenarios might affect tree vitality.

From this study, it becomes apparent that the data from young trees showing that weeds negatively impact tree growth (Merwin and Stiles 1994) and, ultimately, production, may not apply to mature trees. Thus, until further long term studies are conducted, we would conclude that a grower need not go to great lengths to maintain a weed free strip simply to increase yield or fruit size. There may be other reasons, such as vole control, irrigation blockage, etc., to maintain a weed free strip, but tree vigor and fruiting should not be one of those reasons.

Outreach

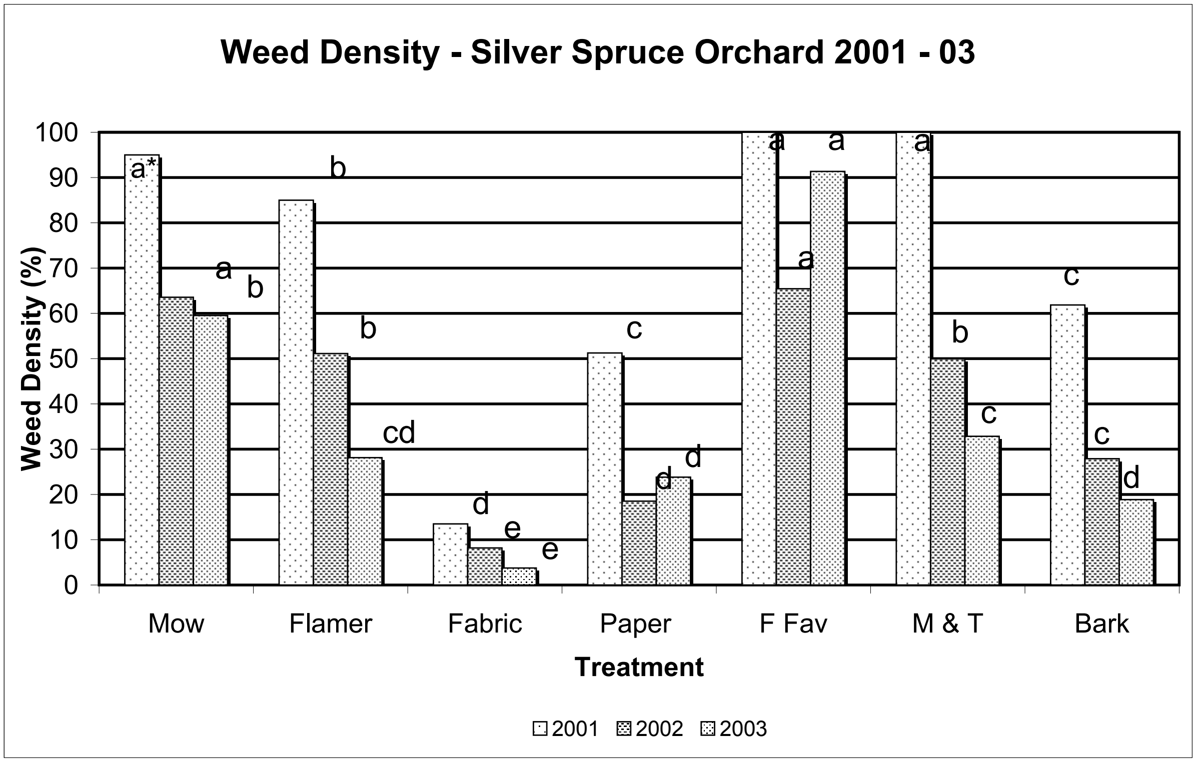
Results of this project have been presented at the Colorado Organic Producers Association annual meetings in 2004 and 2005. Year two results were also presented and discussed at the 2nd National Organic Tree Fruit Research Symposium in 2003. Additionally, results from this study may be included in a Gerber Products, Inc., growers newsletter. During the course of the study, results were presented at a Colorado growers organic education meeting sponsored by Colorado State University and the the Colorado Organic Crop Management Association in the spring of 2001. In addition, this study has been discussed informally at grower brown bag lunches at our local Colorado State University research center. Finally, the study has been highlighted as part of a tour for national and regional EPA personnel in 2002, 2003, 2004 and 2005.

Works Cited

Merwin, I.A., and W.C. Stiles. 1994. Orchard groundcover management impacts on apple tree growth and yield, and nutrient availability and uptake. J. Am. Soc. Hort. Sci. 119:209-215.

SAS Institute. 2001. SAS/STAT user's guide. Release 8.2. SAS Institute, Cary, NC.

Figure 1. Weed Density - Silver Spruce, 2001-03.



* Different letter within the same year indicates significant differences between means ($P < 0.05$).

Figure 2. Weed Density - Rogers Mesa, 2001-03.

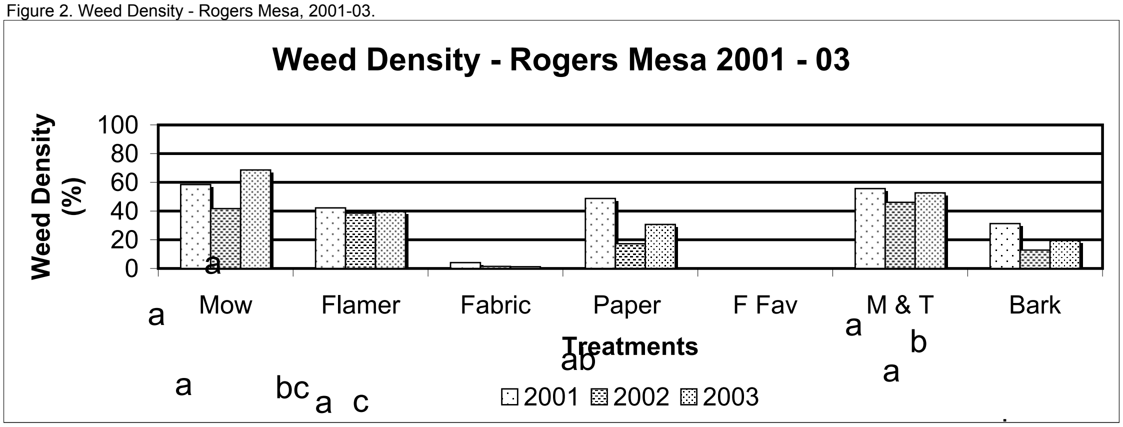
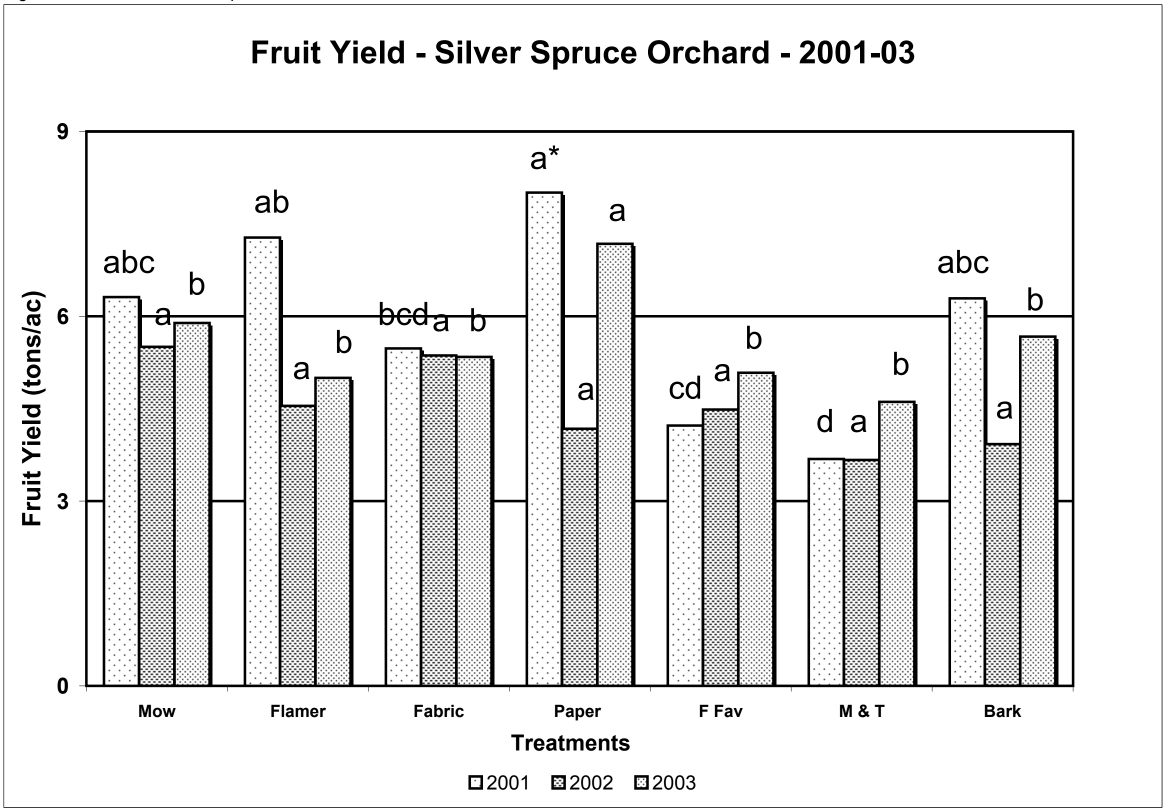
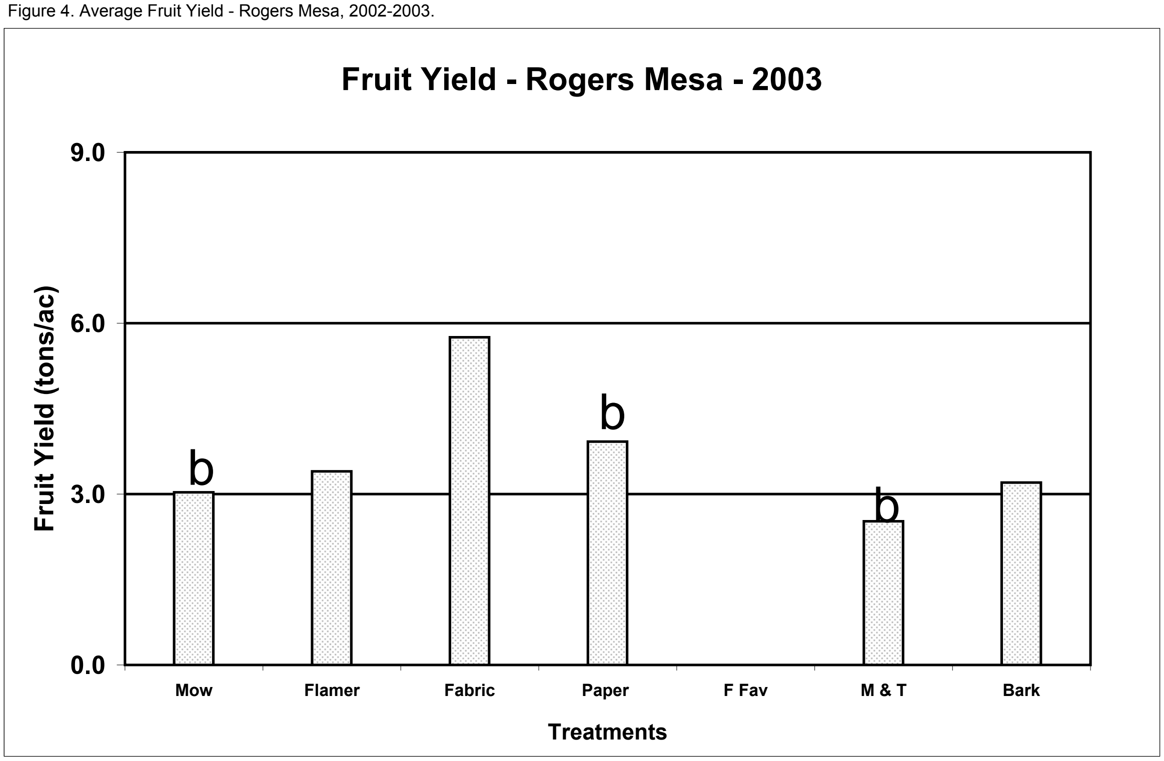


Figure 3. Fruit Yield - Silver Spruce Orchard, 2001-2003.



* Different letter within the same year indicates significant differences between means ($P < 0.05$).

Figure 4. Average Fruit Yield - Rogers Mesa, 2002-2003.



* Different letter indicates significant differences between means ($P < 0.05$).

Figure 5. Tree Growth, 3 year total, Silver Spruce Orchard.

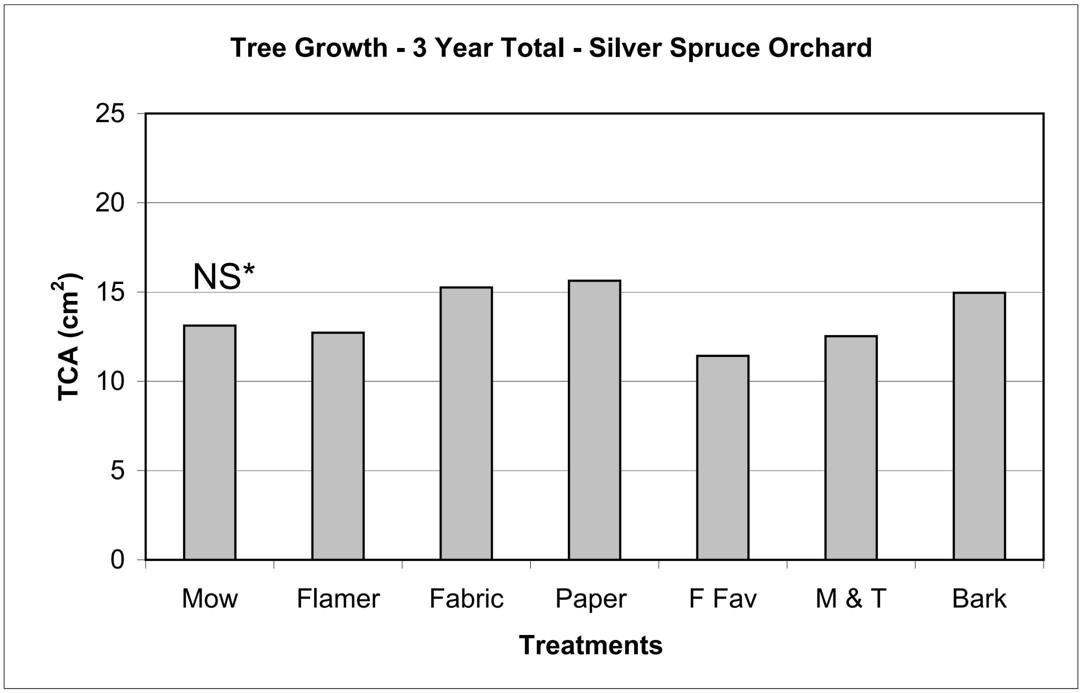


Figure 6. Tree Growth, 3 year total, Rogers Mesa.

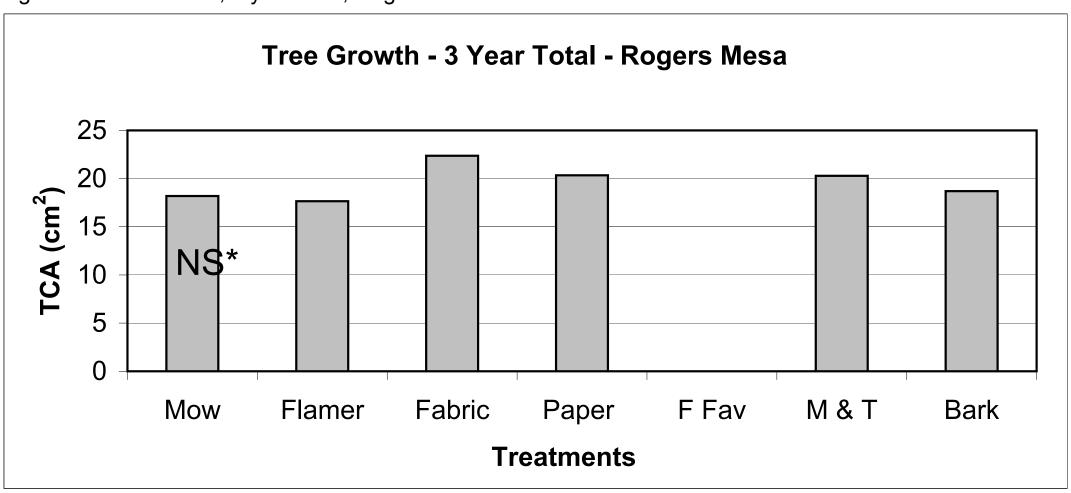


Figure 7. Leaf Nitrogen - Silver Spruce Orchard, 2001-03.

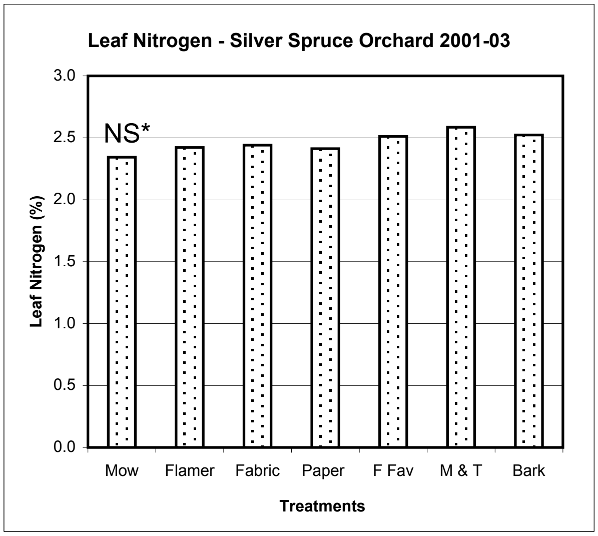


Figure 8. Leaf Nitrogen - Rogers Mesa 2001-03.

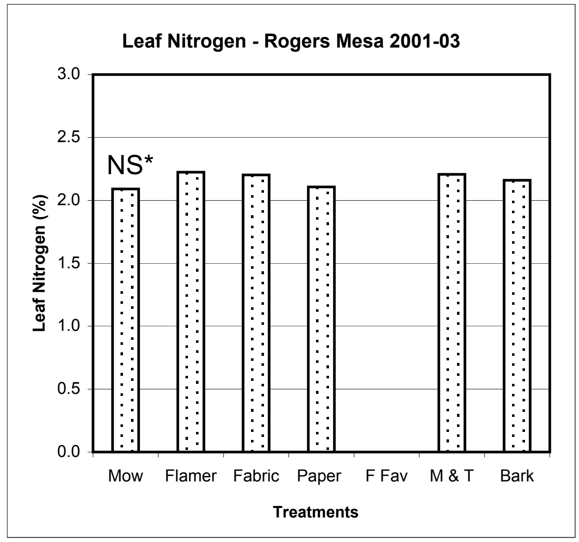


Figure 9. Leaf Phosphorus - Silver Spruce Orchard, 2001-03.

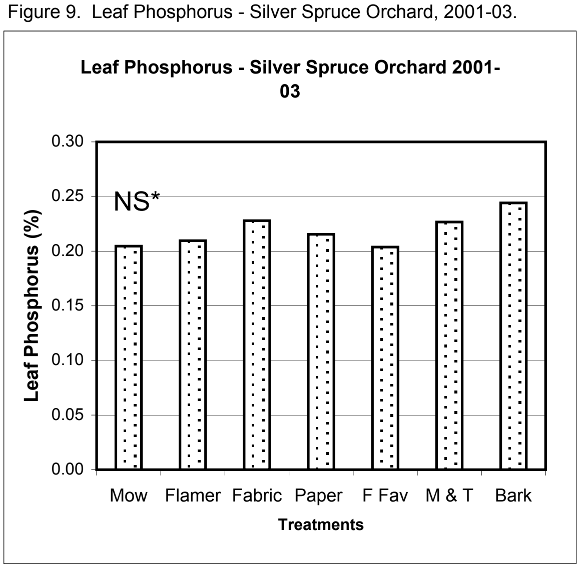


Figure 10. Leaf Phosphorus - Rogers Mesa 2001-03.

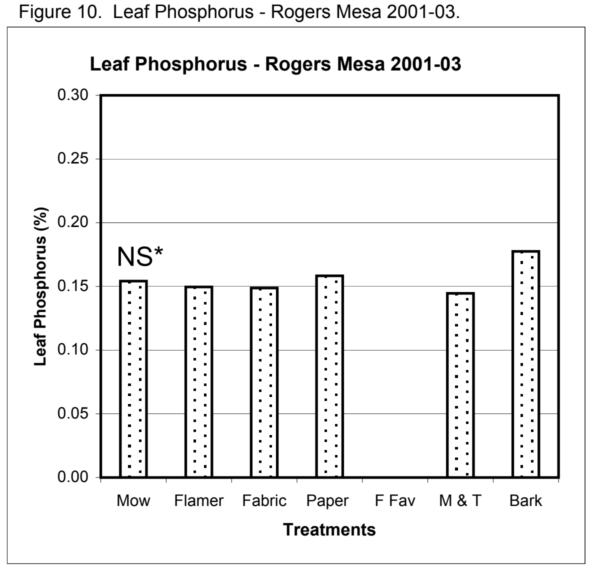


Figure 11. Leaf Potassium - Silver Spruce Orchard, 2001-03.

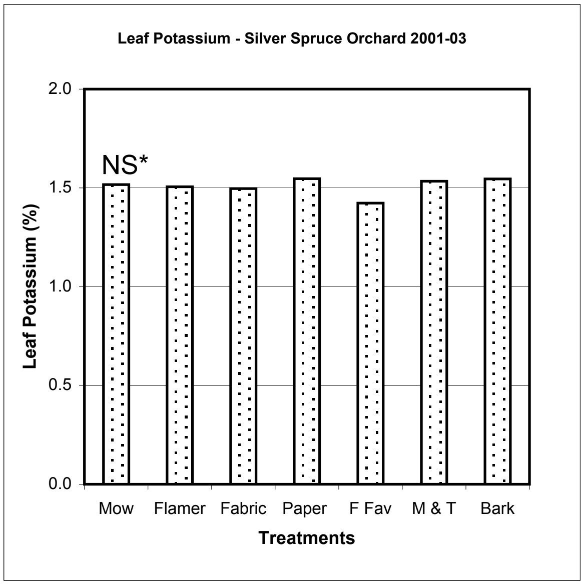
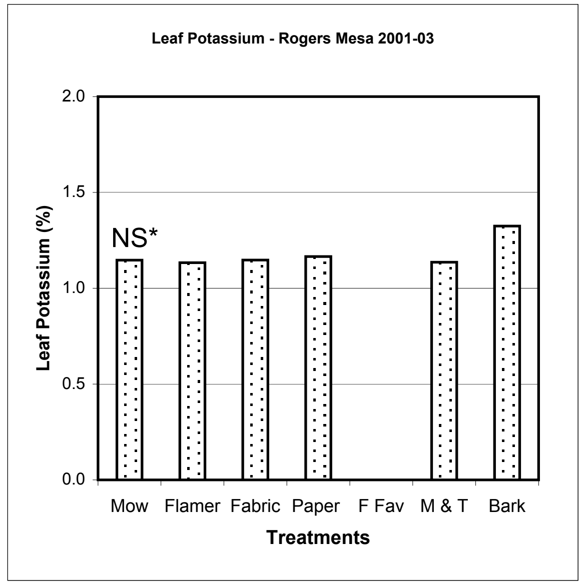


Figure 12. Leaf Potassium - Rogers Mesa 2001-03.



* Differences not significant ($P < 0.05$).

Figure 13. Leaf Sulfur - Silver Spruce Orchard, 2001-03.

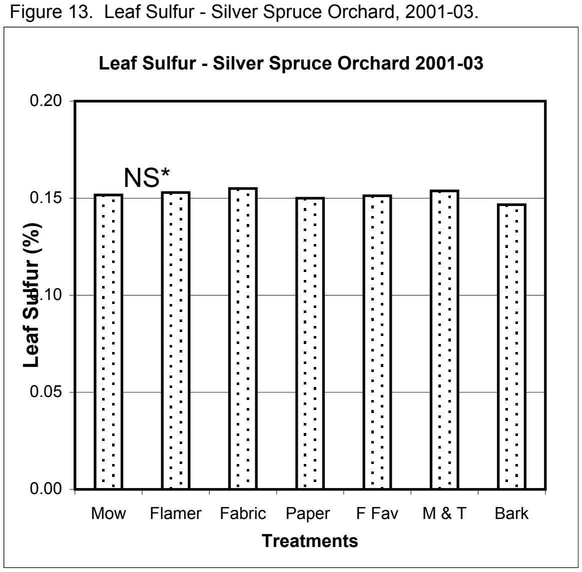


Figure 14. Leaf Sulfur - Rogers Mesa 2001-03.

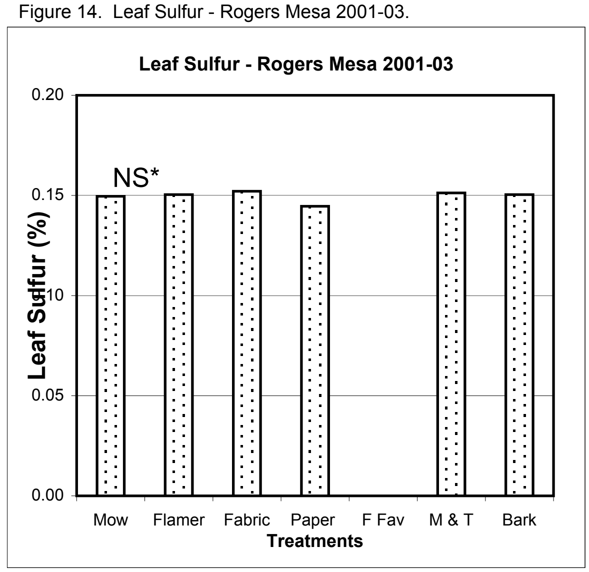


Figure 15. Leaf Calcium- Silver Spruce Orchard, 2001-03.

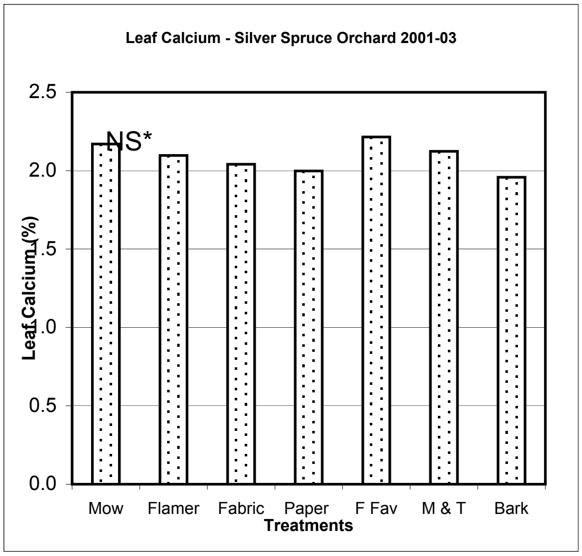


Figure 16. Leaf Calcium - Rogers Mesa 2001-03.

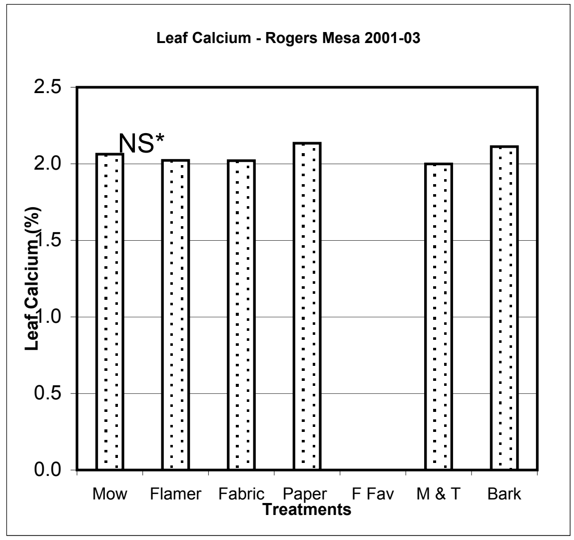


Figure 17. Leaf Boron - Silver Spruce Orchard, 2001-03.

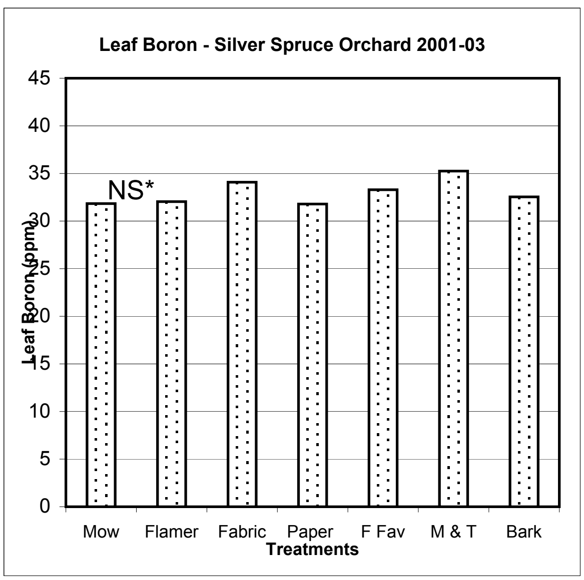
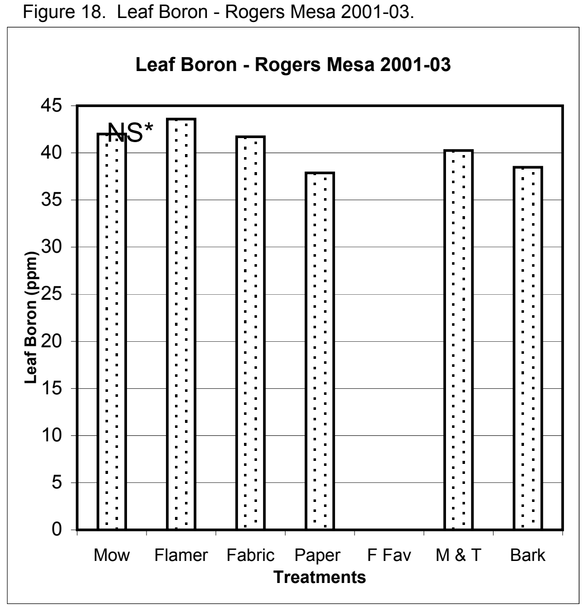


Figure 18. Leaf Boron - Rogers Mesa 2001-03.



* Differences not significant *(P* < 0.05).

Figure 19. Leaf Zinc - Silver Spruce Orchard, 2001-03.

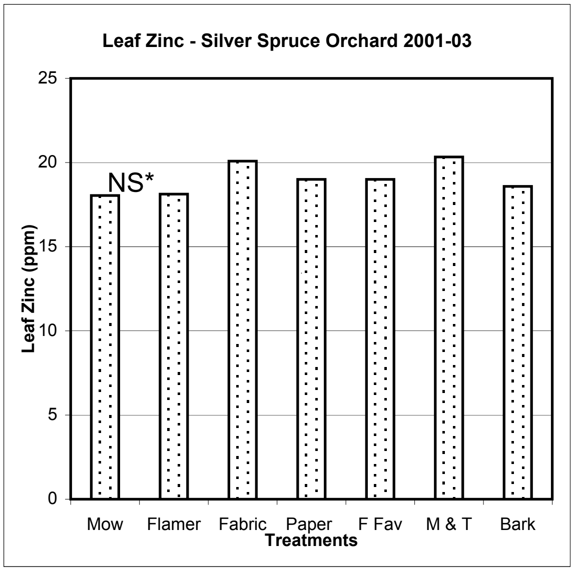


Figure 20. Leaf Zinc - Rogers Mesa 2001-03.

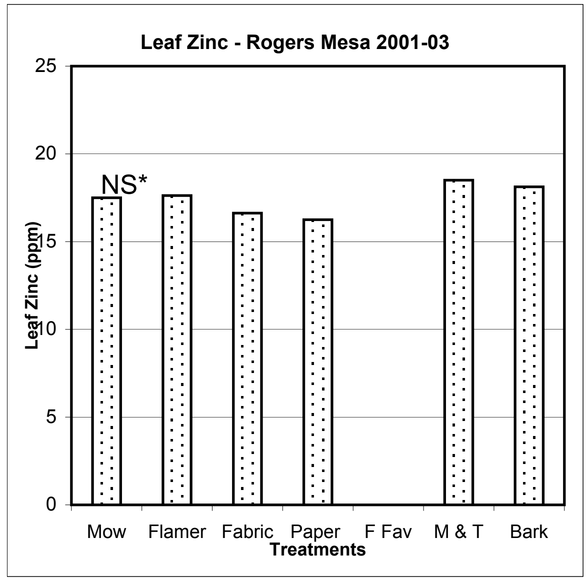


Figure 21. Leaf Manganese - Silver Spruce Orchard, 2001-03

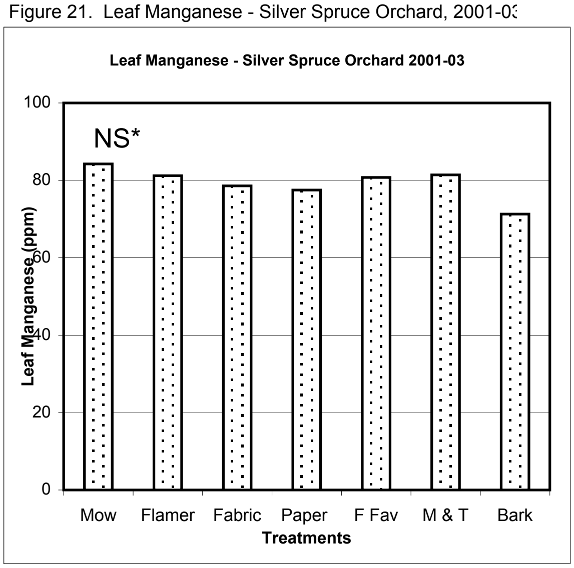


Figure 22. Leaf Manganese - Rogers Mesa 2001-03.

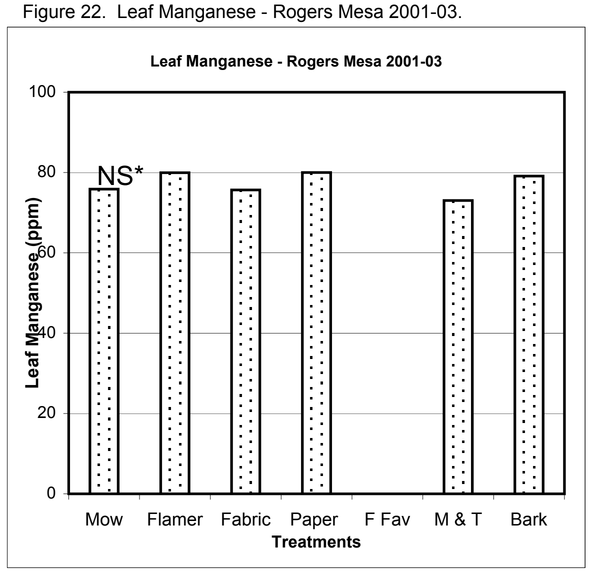


Figure 23. Leaf Iron - Silver Spruce Orchard, 2001-03.

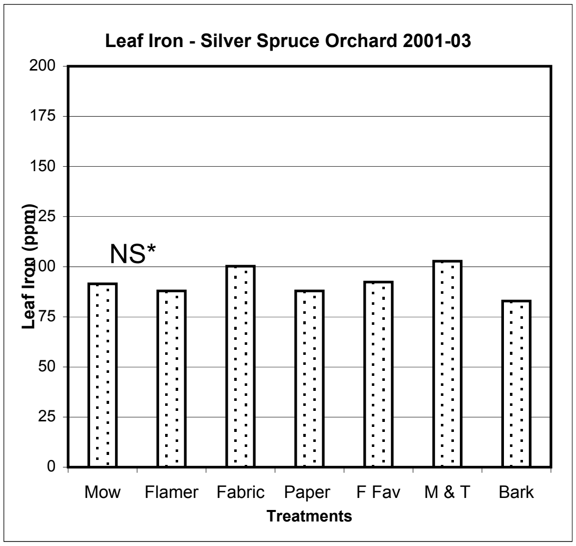
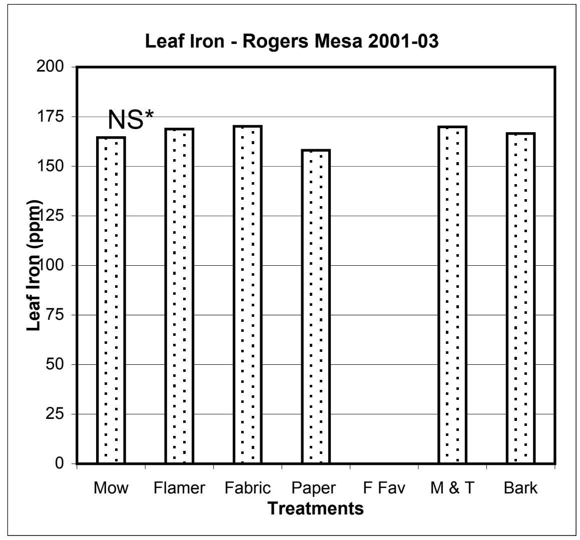


Figure 24. Leaf Iron - Rogers Mesa 2001-03.



* Differences not significant *(P* < 0.05).

Figure 25. Soil NO_3-N - Silver Spruce Orchard 2001-03.

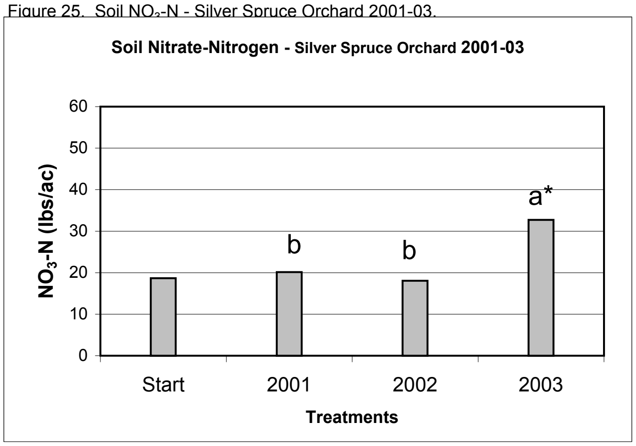


Figure 26. Soil NO_3-N - Rogers Mesa 2001-03.

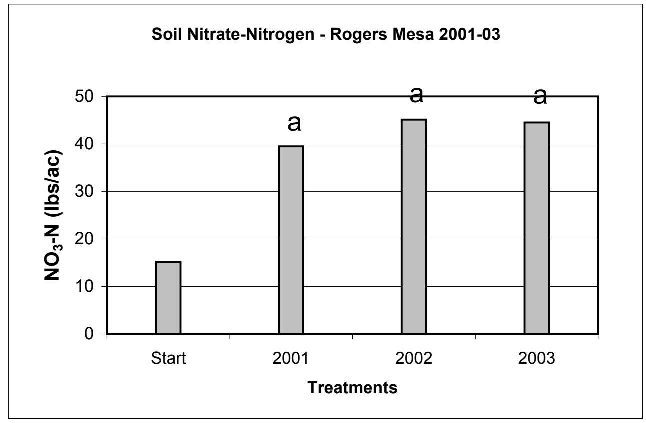


Figure 27. Soil NH_4-N - Silver Spruce Orchard 2001-03.

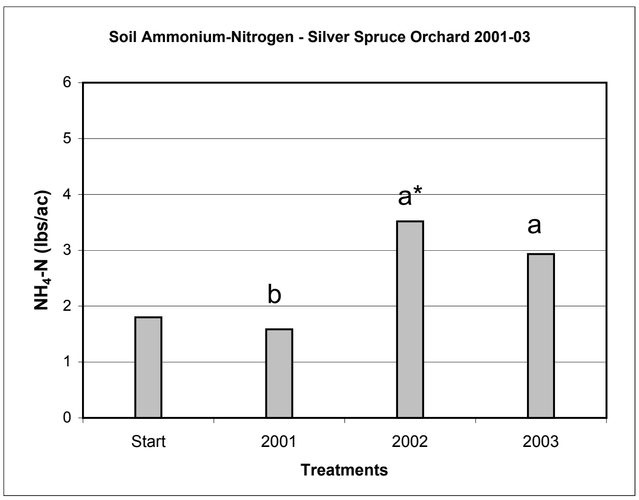
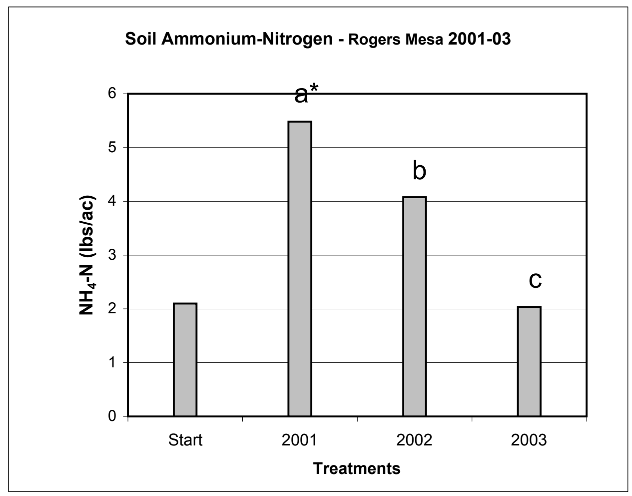


Figure 28. Soil NH_4-N - Rogers Mesa 2001-03.



* Different letter indicates significant differences between means ($P < 0.05$).

Appendix A. Weather statistics for Rogers Mesa 2001-03.

2001	Max Temp degF	Min Temp degF	Vapor Press mb	Solar Rad Lngly	Prec in.	Wind Run mi.	Min5cm Soil degF	Min RH %	Grow DgDy F.	Ref ET in.
Jan-05	40.6	16.1	3.3	229.6	0.45	89.3	27.4	40.3		1.20
Feb-05	47.6	24.4	4.5	264.4	0.72	107.5	33.0	35.8		1.63
Mar-05	56.2	31.2	5.7	376.5	1.41	107.2	40.0	32.5	46.9	3.20
Apr-05	66.1	37.9	5.5	481.1	0.63	132.3	44.8	21.5	214.9	5.47
May-05	78.0	44.5	7.5	593.1	1.48	93.6	54.8	19.8	554.8	7.81
Jun-05	89.0	51.2	7.9	493.0	0.38	100.9	65.6	13.5	1063.6	9.26
Jul-05	91.8	58.8	12.8	435.0	1.37	83.8	70.5	21.0	1700.6	8.35
Aug-05	88.8	56.2	13.4	489.3	1.62	82.0	67.0	25.2	2368.7	7.49
Sep-05	85.5	48.7	8.3	486.3	0.19	81.4	62.9	16.6	2934.4	6.36
Oct-05	69.9	38.0	6.2	345.6	0.73	74.8	53.9	22.3	3206.0	3.67
Nov-05	56.6	30.8	5.8	249.3	0.86	70.8	46.2	34.8		1.84
Dec-05	40.4	19.6	3.9	193.0	0.55	65.4	34.7	43.9		0.82
2001	**67.5**	**38.1**	**7.1**	**4636**	**10.39**	**1089**	**50.1**	**27.3**	**3206**	**57.1**

2002	Max Temp degF	Min Temp degF	Vapor Press mb	Solar Rad Lngly	Prec in.	Wind Run mi.	Min5cm Soil degF	Min RH %	Grow DgDy F.	Ref ET in.
Jan-06	40.1	17.5	3.4	204.2	0.20	70.6	32.0	39.1		1.06
Feb-06	43.5	16.9	3.0	308.8	0.07	77.7	31.2	28.4		1.54
Mar-06	54.0	24.1	3.7	438.5	0.52	103.2	36.3	20.9	41	3.46
Apr-06	70.6	38.5	5.0	524.1	0.63	118.3	48.1	15.1	282	6.03
May-06	78.1	42.2	5.2	594.5	0.05	97.6	54.9	11.9	628	8.16
Jun-06	92.0	53.3	6.8	484.6	0.03	94.2	65.5	9.9	1149	9.66
Jul-06	95.9	59.4	10.9	359.5	0.34	87.4	71.5	15.7	1814	8.72
Aug-06	90.2	54.7	9.3	487.7	0.69	80.7	69.0	17.0	2477	8.06
Sep-06	77.6	48.8	10.8	407.3	3.26	70.0	62.5	30.1	3012	4.84
Oct-06	63.8	35.5	6.7	338.4	2.11	66.9	51.0	31.1	3208	3.08
Nov-06	50.2	24.9	4.7	239.1	0.46	59.7	40.6	36.5		1.36
Dec-06	43.4	20.5	4.0	200.7	0.27	55.7	35.4	42.7		0.90
2002	**66.6**	**36.4**	**6.1**	**4587**	**8.63**	**982**	**49.8**	**24.9**	**3208**	**56.9**

2003	Max Temp degF	Min Temp degF	Vapor Press mb	Solar Rad Lngly	Prec in.	Wind Run mi.	Min5cm Soil degF	Min RH %	Grow DgDy F.	Ref ET in.
Jan-07	48.4	23.1	4.5	221.7	0.17	57.2	34.5	42.7		1.16
Feb-07	44.6	23.0	4.5	247.5	0.90	63.2	35.5	40.6		1.27
Mar-07	55.9	29.6	4.9	393.4	0.57	80.7	41.1	27.7	56	3.10
Apr-07	65.4	36.1	4.6	483.5	0.27	112.3	47.5	16.9	224	5.28
May-07	76.6	44.5	8.0	535.2	1.33	90.4	55.6	19.4	511	7.04
Jun-07	85.6	50.2	8.2	634.8	0.23	85.1	64.7	13.9	1027	9.36
Jul-07	98.1	59.1	10.6	344.6	0.31	77.8	73.0	13.7	1635	8.67
Aug-07	91.3	58.3	13.3	439.4	0.18	67.0	73.4	23.1	2344	7.09
Sep-07	80.0	45.4	8.4	467.7	1.42	62.3	63.0	21.1	2906	5.25
Oct-07	73.2	40.4	6.3	376.1	0.42	68.0	56.3	19.8	3144	3.91
Nov-07	48.5	27.6	5.3	204.2	0.85	54.1	43.6	40.7		1.27
Dec-07	41.7	20.3	4.1	185.6	0.40	43.1	34.7	45.1		0.68
2003	**67.4**	**38.1**	**6.9**	**4534**	**7.05**	**861**	**51.9**	**27.0**	**3144**	**54.1**