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ALFALFA RESEARCH: Quantitative and Qualitative Response of Established Alfalfa Forage to Methods of Application of Phosphorus and Potassium Fertilizers

Report for 1991-92

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BACKGROUND

Although alfalfa is the predominant forage grown on the Canadian prairies, management of fertilizer applications to produce the optimum yield and quality is often neglected. Only about 15% of the alfalfa grown on the prairies is fertilized annually, and that if generally with low rates of P. Therefore, P and K may often be inadequate to produce the most economic yield. Since these two nutrients are relatively immobile in the soil, their availability to the plant may be strongly influenced by the method of placement. The P and K that is applied to alfalfa in the prairies is generally applied as a broadcast application, which may not be readily available to the plant under dry conditions. This study was undertaken to evaluate the effect of broadcast and banded applications of P and K on the yield and quality of established alfalfa stands.

OBJECTIVE

To evaluate application techniques that may increase the availability of P and K fertilizer to alfalfa, thus resulting in increased forage yield and improved protein and mineral composition.

METHODOLOGY

Two research sites were selected in 1989. The first was a Marringhurst sandy loam soil near Brandon and the second a Newdale clay loam soil, near Newdale, MB. Each site had been sown to Algonquin alfalfa three years previously and had been cut for two years. Neither had been fertilized in the previous year. Uniform areas were selected for the experimental site. In 1989, fertilizer was applied to the Marringhurst sandy loam on May 30 and harvests were taken on June 21, July 27 and September 27. Fertilizer was applied to the Newdale clay loam soil on May 26 and harvests were taken on June 27, August 1 and September 27. In 1990, fertilizer was applied in the first week of May on both sites. Harvests were taken on the Marringhurst soil on June 21, July 27 to August 2 and September 27. On the Newdale soil, harvests were taken on June 19-20 and July 24-26. No third harvest was taken on the Newdale soil in 1990, due to insufficient regrowth. In 1991, fertilizer was applied on April 18 on the Newdale site and April 19 on the Marringhurst site. Harvests were taken on June 10 and July 19 on the Newdale soil and June 11, July 17 and September 20 on the Marringhurst soil. Plant samples were dried, ground and submitted to the laboratory for analysis for N, P and K. Statistical analysis was conducted using the GLM procedure of SAS (SAS Institute 1982).

RESULTS AND DISCUSSION

DRY MATTER YIELD

1989 Crop Year

Marringhurst Sandy Loam

Alfalfa yield on the sandy loam soil was extremely high (Table 1). The site was

located in a depressional area and received ample moisture. The stand was thick, lush and productive. Dry matter yield at the first harvest was reduced by the banding operation (Tables 1 and 2). By the second harvest, differences due to placement were no longer significant. Total dry weight production over the season was lower with banded rather than broadcast fertilizer application. Dry matter yield at the first and third harvests were not significantly influenced by fertilizer application. However, yield at the second harvest was increased with application of K. Fertilizer P and K tended to increase yield at the final harvest. Total dry weight production over the season was increased by application of K.

Table 1: Yield of alfalfa on the Marringhurst sandy loam soil as influenced by method and rate of P and K fertilization (1989).

P	K	Placement	Harvest 1	Harvest 2	Harvest 3	Total
-kg ha^{-1}-			----------t ha^{-1}----------			
0	0	Broadcast	5.4	4.8	2.3	12.6
0	0	Banded	4.7	4.6	2.4	11.7
0	50	Broadcast	5.1	4.9	2.5	12.5
0	50	Banded	4.9	5.0	2.2	12.2
0	100	Broadcast	6.0	5.4	2.4	13.7
0	100	Banded	4.6	4.9	2.6	12.1
20	0	Broadcast	4.5	4.2	2.2	10.8
20	0	Banded	4.0	4.7	2.6	11.3
20	50	Broadcast	6.2	5.0	2.2	13.4
20	50	Banded	4.6	5.7	2.6	12.9
20	100	Broadcast	5.5	4.8	2.5	12.8
20	100	Banded	4.8	5.0	2.4	12.2
40	0	Broadcast	4.9	4.7	2.1	11.6
40	0	Banded	4.7	4.6	2.6	11.9
40	50	Broadcast	5.5	5.1	2.4	13.0
40	50	Banded	4.2	4.4	2.2	10.8
40	100	Broadcast	5.8	4.7	2.6	13.1
40	100	Banded	4.8	4.9	2.3	11.9
80	0	Broadcast	5.4	4.5	2.5	12.3
80	0	Banded	4.9	5.0	2.5	12.4
80	50	Broadcast	5.6	5.1	2.3	13.0
80	50	Banded	5.0	5.2	2.7	13.0
80	100	Broadcast	5.4	4.9	2.2	12.6
80	100	Banded	4.5	4.8	2.6	12.0

Newdale Clay Loam

Yield on the clay loam soil was low, due to dry conditions throughout the growing season. The banding operation did not depress yield as strongly as it did in the sandy soil, possibly because the dry conditions reduced the number of roots near the surface. Dry matter yield at the first and second harvests were not significantly influenced by fertilization (Tables 2 and 3). By the third harvest, yield was increased with application of P at 20 kg ha^{-1} and increased further with the application of 40 or 80 kg P ha^{-1}. Total dry matter yield through the season increased with increasing P. The highest total yields were obtained when both P and K were applied at moderate to high levels.

Table 3: Yield of alfalfa on the Newdale clay loam soil as influenced by method and rate of P and K fertilization (1989).

P	K	Placement	Harvest 1	Harvest 2	Harvest 3	Total
-kg ha^{-1}-			----------t ha^{-1}----------			
0	0	Broadcast	1.2	1.4	0.9	3.5
0	0	Banded	1.0	1.3	0.7	3.0
0	25	Broadcast	1.0	1.0	0.5	2.5
0	25	Banded	1.2	1.3	0.9	3.4
0	50	Broadcast	1.3	1.4	0.9	3.6
0	50	Banded	1.1	1.1	0.8	3.1
20	0	Broadcast	1.2	1.2	0.9	3.3
20	0	Banded	1.0	1.4	1.0	3.4
20	25	Broadcast	1.2	0.9	1.1	3.2
20	25	Banded	0.9	1.1	0.8	2.8
20	50	Broadcast	0.9	1.4	0.9	3.1
20	50	Banded	1.3	1.6	1.2	4.1
40	0	Broadcast	1.2	1.4	1.0	3.5
40	0	Banded	1.1	1.3	1.2	3.6
40	25	Broadcast	1.5	1.2	1.3	4.0
40	25	Banded	1.4	1.3	1.2	3.9
40	50	Broadcast	1.1	1.4	1.2	3.7
40	50	Banded	1.0	1.3	1.0	3.3
0	0	Broadcast	0.9	1.2	1.0	3.1
80	0	Banded	1.0	1.3	1.2	3.4
80	25	Broadcast	1.2	1.5	1.4	4.1
80	25	Banded	1.2	1.6	1.3	4.1
80	50	Broadcast	1.4	1.7	1.5	4.6
80	50	Banded	1.0	1.6	1.3	3.9

1990 Crop Year

Marringhurst Sandy Loam

In 1990, alfalfa yield on the sandy loam soil although high, was slightly lower than in 1989. Yield of the first harvest was reduced by band placement of fertilizer (Tables 4 and 5). At the later harvests, and for total yield, there was no effect of fertilizer placement. Potassium application increased the first harvest yield but only when the fertilizer was broadcast ($P < 0.052$). On the second harvest, there was no effect of fertilizer application or placement method on alfalfa yield, while at the third harvest, yield increased with application of 50 or 100 kg K ha-1, banded or broadcast.

Table 4: Yield of alfalfa on the Marringhurst sandy loam soil as influenced by method and rate of P and K fertilization (1990).

P	K	Placement	Harvest 1	Harvest 2	Harvest 3	Total
-kg ha^{-1}-			----------kg ha^{-1}----------			
0	0	Broadcast	5.0	3.3	1.6	9.9
0	0	Banded	5.2	3.9	1.2	10.2
0	50	Broadcast	5.3	3.5	1.9	10.7
0	50	Banded	4.6	3.2	1.9	9.7
0	100	Broadcast	5.2	3.1	1.5	9.9
0	100	Banded	4.9	3.5	1.8	10.2
20	0	Broadcast	4.8	2.8	1.4	9.0
20	0	Banded	4.9	3.2	1.7	9.9
20	50	Broadcast	5.6	3.5	2.0	10.6
20	50	Banded	5.1	3.4	1.5	10.0
20	100	Broadcast	5.0	3.6	1.9	10.5
20	100	Banded	4.7	3.3	2.2	10.1
40	0	Broadcast	4.7	3.4	1.5	9.6
40	0	Banded	5.0	3.3	1.5	9.8
40	50	Broadcast	5.2	3.4	2.3	10.9
40	50	Banded	4.5	3.0	1.6	9.1
40	100	Broadcast	4.9	3.5	1.7	10.0
40	100	Banded	4.8	3.4	1.6	9.9
80	0	Broadcast	5.3	3.3	1.7	10.3
80	0	Banded	5.1	3.6	1.5	10.1
80	50	Broadcast	5.3	3.4	1.9	10.7
80	50	Banded	4.9	3.6	1.9	10.3
80	100	Broadcast	5.3	3.3	1.9	10.4
80	100	Banded	4.7	3.5	1.9	10.1

Newdale Clay Loam

In 1990, on the clay loam soil, yield was slightly higher than that in 1989. Adequate early season moisture led to moderate yields at the first and second harvests, but drought during the midsummer reduced regrowth and no third harvest was taken. Yield at the first harvest was increased by P application to 40 kg P ha^{-1} (Tables 5 and 6). At the second harvest, yield was again increased with P application to 40 kg P ha^{-1}, but the yields were higher with banded rather than broadcast fertilization. Presumably, by the second harvest, drying of the soil surface and reaction of the phosphate with the soil to form less soluble reaction products was restricting uptake of the surface broadcast P and availability of the banded P was superior. Final total yield was increased by application of P to 40 kg ha^{-1}, but was not influenced by fertilizer placement. Response to P application tended to be greater where 25 kg K ha^{-1} was applied.

Table 6: Yield of alfalfa on the Newdale clay loam soil as influenced by method and rate of P and K fertilization (1990).

P	K	Placement	Harvest 1	Harvest 2	Harvest 3	Total
-kg ha^{-1}-			----------kg ha^{-1}----------			
0	0	Broadcast	2.4	1.4	.	3.8
0	0	Banded	2.1	1.5	.	3.6
0	25	Broadcast	1.6	1.0	.	2.6
0	25	Banded	2.3	1.5	.	3.7
0	50	Broadcast	2.3	1.3	.	3.6
0	50	Banded	2.3	1.6	.	3.9
20	0	Broadcast	2.4	1.6	.	4.1
20	0	Banded	2.6	2.1	.	4.8
20	25	Broadcast	2.5	2.0	.	4.4
20	25	Banded	2.5	2.0	.	4.5
20	50	Broadcast	2.6	1.8	.	4.4
20	50	Banded	2.9	2.1	.	5.1
40	0	Broadcast	3.2	2.2	.	5.3
40	0	Banded	2.7	2.2	.	4.7
40	25	Broadcast	3.6	2.4	.	6.1
40	25	Banded	3.1	2.3	.	5.4

Table 6 (Cont'd)

P	K	Placement	Harvest 1	Harvest 2	Harvest 3	Total
-kg ha^{-1}-			----------kg ha^{-1}----------			
40	50	Broadcast	3.2	2.2	.	5.4
40	50	Banded	2.5	2.0	.	4.5
80	0	Broadcast	2.8	1.9	.	4.8
80	0	Banded	2.9	2.3	.	5.2
80	25	Broadcast	3.5	2.2	.	5.7
80	25	Banded	3.5	2.7	.	6.2
80	50	Broadcast	3.6	2.4	.	6.0
80	50	Banded	3.1	2.3	.	5.4

1991 Crop Year

Marringhurst Sandy Loam

Although the season started off with poor soil moisture conditions, adequate and timely rainfall throughout the growing season led to high alfalfa yields in 1991, particularly on the Marringhurst soil (Table 7). In spite of the high yields, there was no response of yield to fertilizer application on the Marringhurst soil at the first harvest (Tables 7 and 8). As in the previous years, yield was reduced at the first harvest by the banding operation, so yield at the first harvest was higher when fertilizer was broadcast as compared to banded. At the second harvest, there was a slight reduction in yield with application of low levels of P, but not when 80 kg P_2O_5 ha^{-1} was applied. The yield advantage of broadcast as compared to banded fertilizer applications was less at the second than the first harvest, indicating a recovery from damage due to banding. There was a K*placement interaction, which reflected an increase in yield when K was broadcast but not when K was banded. At the third harvest, there was no response to fertilizer application or fertilizer placement. Total yield was not influenced significantly by fertilizer K application, but showed a there was no response to fertilizer application or fertilizer placement. Total

yield was not influenced significantly by fertilizer K application, but showed a quadratic response to P, being lower at 20 or 40 kg P_2O_5 ha^{-1}, than at 0 or 80 kg P_2O_5 ha^{-1}. Total yield was lower when fertilizer was banded than when no fertilizer was applied.

Newdale Clay Loam

On the Newdale clay loam site, soil moisture was low in the spring, but adequate rainfall led to production slightly higher than in 1990 (Table 9). Although insufficient growth occurred to take a third harvest, the stand had considerably more regrowth going into the winter in 1991 than in the previous years of the study. Yield at the first harvest was increased strongly by P application, with yield almost doubling with application of 80 kg P_2O_5 ha^{-1} as compared to treatments which did not receive P (3.21 versus 1.74 t ha^{-1}) (Tables 8 and 9). No response occurred to applications of K. At the second harvest, yield was higher when fertilizer was banded rather than broadcast, and the response to P application was high. Presumably, application of banded P was more available to the plant than the broadcast P later in the season, leading to higher yields where the P deficiency was great. However, the banding procedure itself apparently increased yield somewhat at the second harvest in 1991, since yield was higher with banding even where no fertilizer was applied. Total yield was increased 80% by P application and the highest yield was obtained when the fertilizer was banded.

NUTRIENT CONCENTRATION AND UPTAKE

1989 Crop Year

Marringhurst Sandy Loam

Concentration of N in the alfalfa tissue was sufficient for adequate growth at all harvests (Table 10). Concentration of N in alfalfa tissue at the first harvest in 1989 was increased slightly by P application, but was unaffected by K application or fertilizer placement (Tables 10 and 11). Concentration of N was unaffected by any fertilizer treatments in the second or third harvests. Nitrogen uptake at the first harvest was reduced by band application as compared to broadcast application of fertilizer, reflecting the yield reduction caused by the banding operation, but was unaffected by fertilizer application or placement in the subsequent harvests (Tables 12 and 13).

Phosphorus concentration in the tissue at the first harvest was low, indicating a potential restriction on crop production due to P deficiency, but levels in the second and third harvests were marginal to sufficient (Table 10). Phosphorus concentration in the tissue at the first harvest was increased by application of P and decreased by application of K (Tables 10 and 11). However, P concentration in the tissue at the second and third harvests was unaffected by fertilizer treatment. Phosphorus uptake was reduced by band application as compared to broadcast application at the first harvest, due to the reduced yield (Table 12 and 13). At the second harvest, P uptake was slightly higher when moderate levels of K were applied than when no or high levels were added.

Potassium concentration in the tissue was low to marginal at all harvests (Table 10). Potassium concentration in alfalfa tissue was unaffected by fertilizer treatment at the first harvest, but was increased slightly by high

levels of applied K at the second and third harvests (Tables 10 and 11). Uptake of K in the first and third harvests was increased by K applications (Tables 12 and 13). Uptake of K in the first harvest was reduced slightly by P applications and reduced to a greater extent by band placement of fertilizer.

Sulfur concentration in the tissue was sufficient at the first harvest, but fell to marginal to sufficient levels at the second and third harvests (Table 10). More sulfur may have been available in the soil for production of the first harvest due to accumulation from fall and early spring mineralization. Sulfur concentration in the tissue at the second harvest was reduced slightly by K applications but was unaffected by fertilizer treatments in the first and third harvests (Tables 10 and 11). Sulfur uptake was not influenced by fertilizer treatment at any harvest (Tables 12 and 13).

Calcium and magnesium concentrations were adequate for crop production and were not influenced significantly by fertilizer treatments in any harvest in 1989 (Tables 14 and 15). Uptake of Ca at the first harvest was increased by application of K (Tables 16 and 17).

Zinc concentration in alfalfa tissue at the first harvest was adequate for crop production, but was reduced slightly by the 80 kg P_2O_5 ha^{-1} application (Tables 14 and 15). Concentrations in the later harvests were marginal for crop production but were unaffected by fertilizer treatment. Zinc uptake at the first harvest was reduced by banding, due to the reduction in yield, but fertilizer treatments had no other effect on P uptake at the first or subsequent harvests (Tables 16 and 17).

Copper concentrations in the tissue were marginal at all harvests both for crop production and for animal nutrition (Table 14). Copper concentration was

increased by K application at the first harvest but was not influenced by fertilizer treatments at subsequent harvests (Tables 14 and 15). Copper uptake was also increased by K application at the first harvest, while uptake was reduced due to banding of fertilizers (Tables 16 and 17). Copper uptake was unaffected by fertilizer treatment at the second and third harvests.

Newdale Clay Loam

Nitrogen concentration in alfalfa tissue was adequate for crop production and was unaffected by fertilizer treatment at any harvest in 1989 (Tables 18 and 19). However, N uptake at harvest 2 and 3 was increased with P application, due to the yield response to P (Tables 20 and 21). At harvest 3, there was a P by K interaction, with the increase in uptake being greater when both P and K were supplied.

Phosphorus concentration was marginal for crop production and both concentration and uptake were unaffected by fertilizer treatments at the first harvest (Tables 18 to 21). However, concentration at the second and third harvest was low and both concentration and uptake of P increased with P application. Uptake of P was greatest when both P and K were supplied at high levels.

Potassium concentration in the tissue was low at the first harvest but sufficient at harvests 2 and 3 (Table 18). Potassium concentration and uptake were increased at harvest 2 and 3 by application of P (Tables 18 and 19). Potassium uptake at harvest 3 was also increased by application of K, with uptake being greatest when both P and K were applied at high levels.

Sulfur concentration was low to marginal for crop production in the first

harvest but sufficient in the second and third harvests (Table 18). Sulfur concentration was not influenced by fertilizer treatment at any harvest, but uptake at harvest 2 was increased by banded as compared to broadcast fertilizer application (Table 18 to 21). Uptake at harvest 3 was increased by P and K applications. Changes in uptake reflect changes in yield.

Calcium concentration in the tissue was sufficient for crop production at all harvests (Table 22). Calcium concentration in the tissue at the first harvest was reduced slightly by K application and was increased by band as compared to broadcast fertilizer application (Tables 22 and 23). Calcium uptake at the first harvest was not affected by fertilizer treatment (Tables 24 and 25). At the second harvest, Ca concentration and uptake were increased slightly by K application (Tables 22 to 25). At the third harvest, concentration of Ca was reduced slightly by P application while total uptake increased, indicating a dilution due to the yield increase promoted by P application.

Magnesium concentration was adequate for crop production and was not influenced by fertilizer treatment in any harvest (Tables 22 and 23). However, Mg uptake at harvests 2 and 3 was increased by P application, while uptake at harvest 2 was increased by banded as compared to broadcast fertilizer applications (Tables 24 and 25). This reflects the changes in yield associated with these treatments.

Zinc concentration was adequate for crop production at all harvests (Table 22). Zinc concentration in the tissue at harvests 2 and 3 was reduced by P application, although uptake at harvest 3 was increased (Tables 22 to 25). At high P levels, P may interfere with Zn accumulation by plants. In this case, although Zn concentration in the tissue decreased with P application, the

maintenance or increase in uptake associated with P fertilization indicates the the reduction in concentration may have been due to simple dilution. Zinc uptake at harvest 2 was also increased by banded as compared to broadcast fertilizer applications, reflecting the higher yield associated with the banded treatments.

Copper concentration in the tissue was marginal for both crop production and animal nutrition at all harvests (Table 22). Copper concentration in the tissue at the first harvest decreased with application of K, while concentration at the second and third harvests decreased with P application (Tables 22 and 23). Uptake of Cu was not influenced by fertilizer treatment at any harvest, so the changes in concentration presumably reflect dilution of the Cu by increased dry matter production (Tables 24 and 25).

CONCLUSIONS

In all three years, banding fertilizer disrupted the alfalfa stand in the Marringhurst sandy loam soil, which generally reduced yield in banded compared to broadcast fertilizer treatments at the first harvest. By the third harvest, differences were not significant. However, the total dry matter production over the season was still lower in the banded as compared to the broadcast treatments in 1989 and 1991. In 1990, the difference between placements was not significant, but K fertilizer response was greater where the K was broadcast rather than banded ($p<0.0557$).

In the Newdale clay loam soil, differences between banding and broadcast treatments were less than in the sandy loam soil and banded applications showed

a slight advantage at the second harvest, which was significant in both 1990 and 1991. In 1991, banded fertilizer applications promoted higher second total yields than broadcast applications. This was apparently due both to the effect of the increased fertilizer efficiency and a physical effect of the banding operation, since yields were slightly higher in the unfertilized treatment that had received a banding operation than in the undisturbed unfertilized treatment.

Although total yield was increased slightly on the Marringhurst sandy loam soil by the application of K in 1989 and 1990, in 1991 there was no response to fertilizer addition. The high yield obtained on this site in the absence of applied fertilizers is noteworthy. In contrast, yield on the Newdale clay loam soil was increased substantially by the application of P in all years, although yield was low in comparison the that on the sandy loam.

Phosphorus concentration and uptake was increased by P application where tissue levels were low, indicating that where soil availability was inadequate for crop production, fertilizer amendments were effective in increasing P for crop use. Potassium applications did not influence K concentration in the tissue at the first harvest, but did increase K concentration in the second and third harvests. Concentration and uptake of non-treatment nutrients were generally unaffected by fertilizer additions, or reflected the changes in dry matter yield produced by the fertilizer additions.

Table 2. F values as calculated by general linear models analysis of effects for P and K fertilizer and fertilizer placement on dry matter yield of alfalfa at 3 harvests, on a Marringhurst sandy loam and Newdale clay loam (1989).

		Marringhurst Sandy Loam				Newdale Clay Loam			
Source	DF	Harvest 1	Harvest 2	Harvest 3	Total	Harvest 1	Harvest 2	Harvest 3	Total
P	1	0.04	0.02	0.23	0.04	0.0	6.93**	38.83***	11.71**
K	1	3.71	3.00	0.35	4.70*	0.93	1.57	3.54	2.68
P^2	1	0.95	1.16	0.60	1.77	0.56	0.11	2.82	1.15
K^2	1	0.76	4.48*	0.20	2.02	1.25	0.07	0.25	0.28
P x K	1	1.65	0.47	1.00	1.94	0.73	3.14	2.62	2.96
Placement	1	24.99***	0.28	2.41	5.23*	2.56	0.01	0.08	0.36
P X Placement	1	0.18	0.12	0.76	0.46	0.24	0.04	0.44	0.29
K x Placement	1	2.01	0.74	1.08	2.46	0.10	0.35	0.77	0.20
CV		15.19	12.77	15.33	10.37	26.66	23.67	26.18	20.88

1. *, **, *** P values of 0.05, 0.01 and 0.0001, respectively.

NOTE: Preliminary analysis was conducted and indicated highly significant differences due to harvest and site.

Table 5. F values as calculated by general linear models analysis of effects for P and K fertilizer and fertilizer placement on dry matter yield of alfalfa at 3 harvests, on a Marringhurst sandy loam and a Newdale clay loam (1990).

		Marringhurst Sandy Loam				Newdale Clay Loam			
Source	DF	Harvest 1	Harvest 2	Harvest 3	Total	Harvest 1	Harvest 2	Harvest 3	Total
P	1	0.26	0.22	0.69	0.69	69.05***	117.78***	—	98.88***
K	1	0.37	0.20	6.20*	1.48	1.69	1.04	—	1.63
P^2	1	3.44	1.29	0.04	1.71	8.46**	36.74***	—	19.41***
K^2	1	0.10	0.04	3.60	1.47	0.54	1.73	—	1.05
P x K	1	0.41	0.02	0.10	0.11	1.51	1.72	—	1.83
Placement	1	7.82**	0.53	0.43	1.50	0.90	8.20**	—	0.30
P x Placement	1	0.33	0.02	0.15	0.24	1.98	0.44	—	1.45
K x Placement	1	3.89	0.66	0.69	0.65	0.13	1.19	—	0.46
CV		8.53	14.40	29.70	9.67	16.62	14.36	—	14.63

1. *, **, *** P values of 0.05, 0.01 and 0.0001, respectively.

NOTE: Preliminary analysis was conducted and indicated highly significant differences due to harvest and site.

Table 7. Yield of alfalfa on the Marringhurst sandy loam soil as influenced by method and rate of P and K fertilization (1991).

P	K	Placement	Harvest 1	Harvest 2	Harvest 3	Total
kg ha^{-1}			t ha^{-1}			
0	0	Broadcast	6.00	3.32	2.65	11.97
0	0	Knifed	5.61	3.31	2.80	11.71
0	50	Broadcast	5.83	3.26	3.06	12.15
0	50	Knifed	5.59	3.50	2.65	11.74
0	100	Broadcast	6.14	3.67	2.60	12.41
0	100	Knifed	5.51	3.28	3.31	12.10
20	0	Broadcast	5.74	2.80	2.34	10.89
20	0	Knifed	5.78	3.05	3.10	11.93
20	50	Broadcast	5.99	3.11	2.97	12.08
20	50	Knifed	5.77	2.84	2.90	11.51
20	100	Broadcast	5.96	3.54	2.91	12.41
20	100	Knifed	5.67	3.27	2.79	11.73
40	0	Broadcast	5.86	3.15	2.82	11.84
40	0	Knifed	5.55	3.14	2.49	11.19
40	50	Broadcast	6.10	3.35	2.49	11.93
40	50	Knifed	5.26	2.82	2.72	10.81
40	100	Broadcast	6.24	3.39	2.98	12.61
40	100	Knifed	5.30	3.02	2.75	11.07
80	0	Broadcast	6.15	3.31	2.80	12.25
80	0	Knifed	5.53	3.23	3.10	11.86
80	50	Broadcast	6.04	3.37	2.76	12.17
80	50	Knifed	5.78	3.13	3.03	11.94
80	100	Broadcast	5.94	3.31	3.12	12.36
80	100	Knifed	5.57	3.07	2.89	11.54

Table 8. F values as calculated by general linear models analysis of effects for P and K fertilizer and fertilizer placement on dry matter yield of alfalfa at 3 harvests, on a Marringhurst sandy loam and Newdale clay loam (1991).

		Marringhurst Sandy Loam				Newdale Clay Loam			
Source	DF	Harvest 1	Harvest 2	Harvest 3	Total	Harvest 1	Harvest 2	Harvest 3	Total
P	1	0.08	0.81	0.60	0.04	120.45***	195.21***	—	175.65***
K	1	0.01	3.18	1.94	2.32	2.70	0.09	—	1.62
P^2	1	0.26	7.02**	2.13	4.52*	33.92***	91.25***	—	62.16***
K^2	1	0.01	0.80	0.04	0.17	0.42	0.08	—	0.32
P x K	1	0.14	2.44	0.24	1.20	3.13	1.46	—	2.96
Placement	1	20.88***	4.94*	0.88	8.16**	0.02	26.39***	—	4.64*
P x placement	1	0.21	0.61	0.09	0.52	0.20	0.05	—	0.16
K x placement	1	1.10	4.07*	0.72	3.36	2.60	0.23	—	2.59
CV		7.83	10.79	15.76	7.17	16.34	11.44	—	12.87

1. *, **, *** P values of 0.05, 0.01 and 0.0001, respectively.

NOTE: Preliminary analysis was conducted and indicated highly significant differences due to harvest and site.

Table 9. Yield of alfalfa on the Newdale clay loam soil as influenced by method and rate of P and K fertilization (1991).

P	K	Placement	Harvest 1	Harvest 2	Harvest 3	Total
kg ha^{-1}			t ha^{-1}			
0	0	Broadcast	1.77	1.42	—	3.19
0	0	Knifed	1.86	1.61	—	3.47
0	25	Broadcast	1.39	1.10	—	2.49
0	25	Knifed	1.83	1.60	—	3.43
0	50	Broadcast	1.88	1.27	—	3.15
0	50	Knifed	1.70	1.67	—	3.37
20	0	Broadcast	2.71	2.04	—	4.75
20	0	Knifed	2.72	2.41	—	5.13
20	25	Broadcast	2.61	2.10	—	4.71
20	25	Knifed	2.70	2.37	—	5.07
20	50	Broadcast	2.74	2.06	—	4.80
20	50	Knifed	2.92	2.25	—	5.17
40	0	Broadcast	2.78	2.32	—	5.10
40	0	Knifed	2.79	2.48	—	5.27
40	25	Broadcast	3.34	2.45	—	5.79
40	25	Knifed	3.06	2.72	—	5.78
40	50	Broadcast	3.67	2.58	—	5.64
40	50	Knifed	2.74	2.32	—	5.06
80	0	Broadcast	2.62	2.24	—	4.86
80	0	Knifed	3.17	2.65	—	5.82
80	25	Broadcast	3.35	2.30	—	5.65
80	25	Knifed	3.34	2.71	—	6.05
80	50	Broadcast	3.61	2.48	—	6.09
80	50	Knifed	3.19	2.68	—	5.87

Table 10. Macronutrient concentration (mg g^{-1}) of alfalfa tissue on a Marringhurst sandy loam soil as influence by method and rate of P and K fertilization (1989).

P	K	Placement	N Concentration			P Concentration			K Concentration			S Concentration		
kg ha^{-1}			Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
0	0	Broadcast	33.75	30.75	27.25	1.30	2.45	2.08	17.19	20.17	15.90	3.39	2.59	2.17
0	0	Knifed	32.75	32.75	28.00	1.37	2.83	2.08	16.05	17.16	14.86	4.87	2.60	2.40
0	50	Broadcast	31.25	33.25	29.50	1.20	2.70	2.35	18.61	18.16	15.76	3.28	2.51	2.48
0	50	Knifed	34.75	29.25	29.50	1.32	2.30	2.02	17.13	22.18	19.02	2.90	2.35	2.70
0	100	Broadcast	29.75	32.75	30.75	1.23	2.62	2.24	18.34	21.11	18.49	2.76	2.62	2.60
0	100	Knifed	33.00	31.25	27.25	1.28	2.48	2.00	17.26	23.99	18.07	3.14	2.40	2.41
20	0	Broadcast	34.25	30.00	31.25	1.34	2.44	1.96	16.73	21.94	18.07	3.25	2.50	2.75
20	0	Knifed	32.50	32.00	29.50	1.31	2.52	2.03	16.94	18.58	16.57	3.18	2.79	2.57
20	50	Broadcast	32.50	34.00	31.00	1.26	2.94	2.36	16.92	18.28	15.24	3.63	2.61	2.51
20	50	Knifed	33.00	30.00	25.50	1.32	2.56	2.06	17.44	18.69	14.89	4.55	2.28	2.34
20	100	Broadcast	32.75	33.75	29.75	1.26	2.68	2.21	16.95	20.30	17.83	2.97	2.65	2.50
20	100	Knifed	32.75	28.25	29.75	1.31	2.37	2.11	17.32	21.41	17.19	3.05	2.17	2.52
40	0	Broadcast	32.50	32.75	29.00	1.46	2.68	2.33	18.61	17.69	14.60	3.26	2.75	2.49
40	0	Knifed	35.50	31.75	28.50	1.53	2.57	2.03	17.23	21.00	17.56	5.67	2.70	2.49
40	50	Broadcast	34.50	30.00	30.25	1.38	2.59	2.25	16.36	20.75	17.72	3.23	2.40	2.86
40	50	Knifed	35.00	30.75	28.75	1.45	2.46	1.98	17.07	21.63	16.18	3.54	2.41	2.51
40	100	Broadcast	33.00	29.25	29.25	1.36	2.59	2.07	17.04	20.62	15.99	3.35	2.50	2.60
40	100	Knifed	34.25	32.25	30.75	1.42	2.71	2.17	16.99	21.61	17.13	6.40	2.56	2.76
80	0	Broadcast	32.50	33.25	29.25	1.64	2.84	2.27	18.22	18.48	16.26	5.97	2.69	2.57
80	0	Knifed	33.50	32.50	29.75	1.44	2.68	2.17	17.96	21.72	15.99	3.27	2.68	2.66
80	50	Broadcast	35.75	33.00	27.50	1.30	2.75	2.20	16.18	20.57	16.07	3.88	2.76	2.29
80	50	Knifed	35.25	30.50	30.25	1.48	2.68	2.43	17.31	17.90	15.13	3.45	2.45	2.63
80	100	Broadcast	35.50	30.00	29.50	1.53	2.46	2.11	18.42	24.22	19.02	3.14	2.44	2.74
80	100	Knifed	33.25	31.50	28.75	1.38	2.60	2.21	18.29	21.32	17.61	2.98	2.51	2.41

Table 11. F values as calculated by general linear models analysis of effects for P and K fertilizer and fertilizer placement on tissue macronutrient concentrations of alfalfa on a Marringhurst sandy loam soil over 3 harvests (1989).

		N Concentration			P Concentration			K Concentration			S Concentration		
Source	DF	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
P	1	7.18*[1]	0.04	0.16	27.37***	1.69	2.64	0.83	0.21	0.18	0.63	1.02	1.11
K	1	0.36	1.08	0.38	5.34*	0.73	0.11	0.26	5.89*	6.10*	1.32	5.44*	0.47
P^2	1	0.79	0.58	0.91	1.34	0.04	0.55	1.28	0.10	0.41	0.82	0.01	1.90
K^2	1	2.11	0.08	0.17	2.29	0.15	2.00	0.92	1.39	1.89	0.24	2.15	0.00
P x K	1	3.37	1.35	0.40	0.06	0.79	0.87	0.63	0.02	0.00	0.13	0.17	0.44
Placement	1	1.52	1.58	1.52	1.06	1.87	3.55	0.40	0.30	0.02	0.82	2.07	0.06
P x Placement	1	1.74	0.52	2.70	2.78	0.23	3.35	1.42	0.50	0.60	1.33	0.02	0.00
K x Placement	1	0.04	0.53	0.11	0.07	0.41	0.16	0.26	0.07	0.10	0.26	1.72	0.59
CV		5.25	7.30	6.41	6.92	7.97	8.23	6.71	12.75	9.88	42.03	8.67	8.67

1 *, **, *** P values less than 0.05, 0.01 and 0.0001 respectively.

NOTE: Preliminary analysis was conducted and indicated highly significant differences due to harvest and site.

Table 12. Uptake of macronutrients (kg ha^{-1}) by alfalfa on a Marringhurst sandy loam soil as influenced by method and rate of P and K fertilizer (1989)

			N uptake			P Uptake			K Uptake			S Uptake		
P	K	Placement	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
kg ha^{-1}														
0	0	Broadcast	199.32	159.18	65.24	7.54	12.75	4.94	102.12	107.58	37.27	19.50	13.43	5.20
0	0	Knifed	161.92	148.81	69.98	6.80	12.86	5.18	78.39	77.98	37.09	23.96	11.82	5.99
0	50	Broadcast	171.23	159.90	78.23	6.59	13.08	6.19	101.95	87.24	41.57	18.04	12.08	6.57
0	50	Knifed	184.33	143.08	59.59	6.97	11.31	4.16	90.60	108.68	38.23	15.40	11.51	5.41
0	100	Broadcast	185.40	162.78	82.56	7.61	13.02	6.01	114.12	104.89	49.73	17.11	13.01	7.00
0	100	Knifed	195.82	157.09	76.41	7.49	12.50	5.67	102.29	120.76	51.11	18.36	12.06	6.77
20	0	Broadcast	158.10	135.40	64.91	6.19	11.09	4.08	77.32	99.00	37.47	14.69	11.30	5.72
20	0	Knifed	140.37	143.64	75.64	5.68	11.34	5.21	73.95	83.44	42.41	13.69	12.63	6.59
20	50	Broadcast	200.87	170.24	58.69	7.85	14.71	4.54	104.85	92.39	28.88	22.52	13.11	4.62
20	50	Knifed	166.00	168.90	71.60	6.65	14.39	5.78	87.75	105.21	41.78	22.89	12.81	6.56
20	100	Broadcast	190.22	152.35	69.58	7.31	12.11	5.16	98.55	91.67	41.70	17.24	11.98	5.84
20	100	Knifed	177.69	138.98	78.10	7.13	11.64	5.52	93.56	105.39	45.25	16.54	10.73	6.61
40	0	Broadcast	169.84	168.26	63.19	7.66	13.73	5.00	97.93	91.66	32.00	17.08	14.10	5.42
40	0	Knifed	171.72	136.56	68.34	7.36	10.95	4.87	83.40	91.80	41.93	25.69	11.64	5.97
40	50	Broadcast	204.62	160.08	79.46	8.19	13.91	5.90	96.91	109.36	46.54	19.18	12.81	7.52
40	50	Knifed	138.82	121.82	52.75	5.79	9.81	3.64	67.43	85.89	29.54	14.18	9.57	4.60
40	100	Broadcast	207.86	139.24	79.35	8.61	12.30	5.60	107.24	98.33	43.43	21.16	11.86	7.04
40	100	Knifed	142.02	133.52	61.10	5.89	11.11	4.31	70.58	87.46	34.02	26.99	10.51	5.48
80	0	Broadcast	157.59	137.74	72.19	7.92	11.70	5.61	88.28	76.79	40.11	27.04	11.10	6.39
80	0	Knifed	178.77	156.38	70.01	7.65	12.91	5.07	94.98	104.55	37.31	17.23	12.91	6.26
80	50	Broadcast	205.61	184.60	62.90	7.48	15.30	5.00	93.10	116.26	36.38	22.04	15.58	5.24
80	50	Knifed	167.14	159.49	88.47	7.01	13.91	7.14	81.66	93.56	43.96	16.37	12.83	7.74
80	100	Broadcast	215.91	146.35	59.46	9.32	11.95	4.24	111.92	117.69	38.32	19.11	11.91	5.53
80	100	Knifed	169.86	159.01	75.52	7.03	13.14	5.81	93.36	107.67	46.29	15.25	12.69	6.35

Table 13. F values as calculated by general linear models analysis for effects of P and K fertilizer and fertilizer placement on uptake of macronutrients by alfalfa grown on a Marringhurst sandy loam soil over 3 harvests (1989)

		N Uptake			P Uptake			K Uptake			S Uptake		
Source	DF	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
P	1	0.03	0.06	0.01	3.91	0.58	0.17	0.27	0.12	0.43	0.25	0.48	0.10
K	1	3.70	0.00	0.91	1.87	0.01	0.61	6.52*1	3.57	5.67*	0.14	0.54	0.92
P^2	1	1.65	2.41	1.00	1.19	1.57	2.14	4.66*	1.56	2.59	0.14	1.25	0.33
K^2	1	0.17	2.32	0.23	0.82	4.20*	0.21	0.38	0.11	1.68	0.08	0.50	0.09
P x K	1	0.05	0.02	1.46	0.18	0.00	1.33	0.66	0.05	1.58	0.16	0.04	1.66
Placement	1	8.42**	2.12	0.08	11.22**	2.55	0.00	14.86**	0.10	0.46	0.13	2.29	0.33
P x placement	1	0.54	0.27	2.11	1.54	0.25	2.07	0.18	0.18	0.13	1.78	0.12	0.63
K x placement	1	1.14	0.00	0.29	1.75	0.00	0.02	0.99	0.24	0.20	0.00	0.10	0.52
CV		15.29	14.21	17.22	12.88	14.04	20.65	14.31	19.20	16.39	34.63	16.43	18.52

1 *, **, *** P values less than 0.05, 0.01 and 0.0001, respectively.

Note: Preliminary analysis was conducted and showed highly significant differences due to harvest and site.

Table 14. Secondary and micronutrient concentration (mg g^{-1}) of alfalfa tissue on a Marringhurst sandy loam soil as influenced by method and rate of P and K fertilization (1989)

			Ca Concentration			Mg Concentration			Zn Concentration			Cu Concentration		
P	K	Placement	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
kg ha^{-1}														
0	0	Broadcast	17.95	14.28	17.64	5.32	3.63	3.38	0.0249	0.0198	0.0168	0.00525	0.00484	0.00416
0	0	Knifed	12.76	14.06	19.84	6.14	4.25	4.52	0.0245	0.0213	0.0191	0.00491	0.00484	0.00439
0	50	Broadcast	16.64	13.36	18.83	4.99	4.40	4.62	0.0261	0.0214	0.0179	0.00570	0.00518	0.00405
0	50	Knifed	20.17	14.04	21.19	5.18	3.21	3.35	0.0243	0.0195	0.0163	0.00578	0.00480	0.00469
0	100	Broadcast	15.58	15.15	20.60	3.96	4.09	4.08	0.0249	0.0230	0.0181	0.00540	0.00540	0.00405
0	100	Knifed	21.23	13.58	18.53	4.93	4.53	3.35	0.0253	0.0205	0.0178	0.00551	0.00472	0.00442
20	0	Broadcast	19.94	13.32	21.11	5.54	3.69	4.22	0.0256	0.0200	0.0179	0.00559	0.00465	0.00431
20	0	Knifed	18.70	14.60	20.60	5.26	4.51	4.57	0.0287	0.0229	0.0184	0.00559	0.00529	0.00412
20	50	Broadcast	19.59	13.80	19.28	5.43	4.39	4.36	0.0260	0.0208	0.0174	0.00540	0.00480	0.00442
20	50	Knifed	16.31	12.78	17.15	6.26	4.17	4.39	0.0261	0.0205	0.0188	0.00514	0.00495	0.00458
20	100	Broadcast	20.85	14.16	17.59	4.99	4.82	4.40	0.0251	0.0208	0.0169	0.00581	0.00491	0.00428
20	100	Knifed	22.99	12.77	19.56	5.48	3.18	4.05	0.0285	0.0197	0.0207	0.00611	0.00442	0.00446
40	0	Broadcast	19.51	14.21	18.61	4.53	4.64	4.51	0.0282	0.0228	0.0182	0.00521	0.00551	0.00431
40	0	Knifed	14.90	15.48	21.45	6.85	4.18	3.71	0.0272	0.0214	0.0160	0.00525	0.00548	0.00424
40	50	Broadcast	20.65	13.46	20.94	5.41	3.93	4.41	0.0243	0.0194	0.0175	0.00548	0.00461	0.00431
40	50	Knifed	19.94	13.20	18.74	5.80	3.95	4.17	0.0266	0.0206	0.0163	0.00521	0.00480	0.00428
40	100	Broadcast	18.00	14.15	20.56	5.06	4.17	4.52	0.0261	0.0213	0.0185	0.00532	0.00499	0.00439
40	100	Knifed	14.57	13.35	21.07	7.18	3.88	4.65	0.0239	0.0202	0.0174	0.00499	0.00442	0.00401
80	0	Broadcast	12.99	14.08	19.54	6.30	4.62	4.78	0.0206	0.0224	0.0174	0.00439	0.00502	0.00428
80	0	Knifed	18.34	13.74	20.94	4.97	3.56	3.96	0.0237	0.0211	0.0183	0.00499	0.00450	0.00442
80	50	Broadcast	19.83	15.59	18.56	5.83	3.84	3.57	0.0251	0.0209	0.0184	0.00544	0.00446	0.00454
80	50	Knifed	19.66	13.64	20.15	5.21	4.41	5.12	0.0271	0.0242	0.0184	0.00548	0.00502	0.00428
80	100	Broadcast	18.50	14.07	21.84	4.94	3.04	3.25	0.0229	0.0182	0.0147	0.00574	0.00450	0.00398
80	100	Knifed	20.71	14.04	17.42	4.59	3.80	3.72	0.0242	0.0200	0.0166	0.00570	0.00461	0.00394

Table 15. F values as calculated by general linear models analysis for effects of P and K fertilizer and fertilizer placement on tissue secondary and micronutrient concentrations of alfalfa on a Marringhurst sandy loam soil over 3 harvests (1989)

		Ca Concentration			Mg Concentration			Zn Concentration			Cu Concentration		
Source	DF	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
P	1	0.02	0.28	0.40	0.14	0.02	0.08	2.65	0.18	0.44	0.94	2.13	0.45
K	1	2.29	0.43	0.22	1.35	2.17	0.55	0.12	2.64	0.15	4.13*[1]	3.24	0.59
P^2	1	0.30	0.49	0.32	2.31	2.04	2.53	5.65*	0.05	0.03	0.00	0.38	0.05
K^2	1	0.83	0.64	0.59	0.15	0.12	0.37	0.37	0.01	0.03	0.25	0.18	2.44
P x K	1	0.03	0.00	0.05	0.05	1.03	0.67	0.15	4.79*	2,36	1.21	0.89	1.92
Placement	1	0.00	0.86	0.05	1.94	1.53	0.04	1.51	0.03	0.27	0.00	0.48	0.44
P x placement	1	0.20	0.12	0.48	1.94	1.05	0.99	1.00	2.04	0.04	0.23	0.74	2.65
K x placement	1	1.14	2.26	3.34	0.28	0.91	0.02	0.08	0.88	0.45	0.02	2.02	0.00
CV		22.11	9.74	9.79	21.21	15.33	18.66	9.50	7.90	10.98	11.01	8.63	7.65

1 *, **, *** P values less than 0.05, 0.01 and 0.0001, respectively.

NOTE: Preliminary analysis was conducted and indicated highly significant differences due to harvest and site.

Table 16. Uptake of secondary and micronutrients (kg ha^{-1}) by alfalfa on a Marringhurst sandy loam soil as influenced by method and rate of P and K fertilizer (1989).

P	K	Placement	Ca Uptake			Mg Uptake			Zn Uptake			Cu Uptake		
-kg ha^{-1}-			Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
0	0	Broadcast	107.57	74.77	41.78	30.83	18.30	8.28	0.147	0.100	0.040	0.0315	0.0240	0.0100
0	0	Knifed	63.93	63.89	49.50	30.25	19.32	11.29	0.120	0.097	0.048	0.0240	0.0220	0.0111
0	50	Broadcast	90.86	64.59	49.90	27.43	21.53	12.27	0.143	0.102	0.046	0.0312	0.0247	0.0105
0	50	Knifed	107.86	68.61	42.02	27.50	15.78	6.78	0.129	0.095	0.033	0.0307	0.0233	0.0093
0	100	Broadcast	97.76	75.29	55.37	24.64	20.36	10.91	0.155	0.114	0.048	0.0338	0.0268	0.0109
0	100	Knifed	128.08	68.28	52.17	29.13	17.72	9.32	0.151	0.103	0.049	0.0332	0.0236	0.0123
20	0	Broadcast	91.75	59.76	43.81	24.84	16.85	8.79	0.115	0.091	0.0372	0.0262	0.0210	0.0089
20	0	Knifed	79.80	65.74	52.88	22.45	20.50	11.74	0.123	0.103	0.0472	0.0241	0.0240	0.0106
20	50	Broadcast	120.74	69.30	36.07	33.64	21.94	8.42	0.161	0.104	0.0347	0.0333	0.0241	0.0088
20	50	Knifed	82.05	72.03	48.21	31.47	23.35	12.21	0.131	0.115	0.0532	0.0258	0.0279	0.0130
20	100	Broadcast	121.26	63.94	41.15	28.99	21.77	10.29	0.146	0.094	0.0396	0.0339	0.0221	0.0100
20	100	Knifed	121.19	63.05	51.47	29.66	15.58	10.60	0.152	0.097	0.0546	0.0326	0.0218	0.0117
40	0	Broadcast	100.71	73.23	40.91	23.67	23.69	9.75	0.146	0.118	0.0399	0.0271	0.0286	0.0095
40	0	Knifed	74.42	67.51	51.49	32.02	17.79	8.94	0.129	0.093	0.0384	0.0255	0.0238	0.0101
40	50	Broadcast	122.01	71.57	55.01	32.13	21.15	11.58	0.144	0.103	0.0460	0.0323	0.0244	0.0113
40	50	Knifed	78.20	52.20	34.39	22.94	15.83	7.69	0.104	0.082	0.0298	0.0203	0.0189	0.0078
40	100	Broadcast	113.55	67.12	55.69	31.96	19.79	12.24	0.165	0.101	0.0507	0.0336	0.0238	0.0121
40	100	Knifed	60.13	54.86	41.90	30.12	16.11	9.31	0.099	0.084	0.0348	0.0207	0.0184	0.0080
80	0	Broadcast	65.42	58.63	48.61	29.27	19.31	11.90	0.101	0.093	0.0453	0.0215	0.0210	0.0107
80	0	Knifed	99.99	66.10	49.27	26.52	17.12	9.41	0.126	0.101	0.0436	0.0268	0.0217	0.0105
80	50	Broadcast	115.85	87.82	42.48	33.21	20.93	8.39	0.145	0.115	0.0435	0.0316	0.0246	0.0107
80	50	Knifed	90.73	71.41	59.40	24.53	22.96	15.10	0.127	0.127	0.0536	0.0255	0.0264	0.0125
80	100	Broadcast	112.44	68.62	44.02	30.07	14.85	6.55	0.139	0.089	0.0296	0.0348	0.0221	0.0080
80	100	Knifed	105.62	70.84	45.75	23.48	19.20	9.77	0.124	0.101	0.0436	0.0291	0.0233	0.0103

Table 17. F values as calculated by general linear models analysis for effects of P and K fertilizer and fertilizer placement on uptake of secondary and micronutrients by alfalfa grown on a Marringhurst sandy loam soil over 3 harvests (1989).

		Ca Uptake			Mg Uptake			Zn Uptake			Cu Uptake		
Source	DF	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
P	1	0.08	0.19	0.03	0.05	0.01	0.04	2.88	0.15	0.19	1.26	0.42	0.12
K	1	4.69*	0.00	0.14	0.25	0.54	0.02	3.95	0.08	0.14	7.40**	0.17	0.13
P^2	1	0.18	1.86	0.66	0.12	0.17	0.01	0.08	1.29	0.68	1.57	0.27	0.74
K^2	1	0.27	0.80	0.51	0.40	2.62	0.16	0.08	2.32	0.05	0.01	1.42	0.09
P x K	1	0.06	0.14	1.32	0.00	0.25	0.95	0.16	0.69	1.94	0.02	0.06	1.78
Placement	1	2.83	1.41	0.60	1.07	2.36	0.08	6.25*	0.32	0.65	6.69*	0.99	0.66
P x Placement	1	0.00	0.01	0.19	2.36	1.10	1.23	0.13	1.03	0.13	0.00	0.37	0.01
K x Placement	1	0.05	0.18	1.76	0.13	0.22	0.20	1.17	0.01	0.00	0.76	0.21	0.08
CV		29.38	18.08	18.63	20.25	18.77	29.10	16.37	14.38	22.71	20.39	14.95	20.24

1 *, **, *** P values less than 0.05, 0.01, 0.0001, respectively.

NOTE: Preliminary analysis was conducted and showed highly significant differences due to harvest and site.

Table 18. Macronutrient concentration (mg g^{-1}) of alfalfa tissue on a Newdale clay loam soil as influenced by method and rate of P and K fertilization (1989).

P	K	Placement	N Concentration			P Concentration			K Concentration			S Concentration		
kg ha^{-1}			Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
0	0	Broadcast	32.00	32.25	35.25	2.46	1.48	1.62	17.89	22.86	25.31	2.29	3.82	3.46
0	0	Knifed	30.50	32.25	33.00	2.65	1.44	1.51	13.75	20.87	23.22	2.03	4.78	4.13
0	25	Broadcast	28.00	32.25	33.50	2.53	1.30	1.42	15.01	21.64	23.15	1.85	4.09	3.53
0	25	Knifed	28.25	32.25	34.00	2.14	1.50	1.68	18.73	23.70	24.79	1.97	3.06	3.07
0	50	Broadcast	29.00	30.50	33.25	2.32	1.34	1.51	16.17	22.55	22.94	2.01	3.36	3.10
0	50	Knifed	29.25	31.00	32.25	2.35	1.40	1.61	15.84	22.55	24.70	1.96	3.37	3.03
20	0	Broadcast	29.75	32.00	33.00	2.33	1.50	1.70	17.88	23.34	24.39	2.39	3.17	3.16
20	0	Knifed	32.25	31.25	33.00	2.49	1.48	1.61	14.50	22.30	24.12	2.37	3.28	3.31
20	25	Broadcast	28.75	32.20	33.00	2.60	1.51	1.69	14.55	22.11	25.69	1.95	3.91	3.52
20	25	Knifed	29.25	31.00	31.75	2.46	1.47	1.60	14.23	22.44	24.29	2.07	3.92	3.40
20	50	Broadcast	29.50	31.75	35.75	2.52	1.46	1.66	15.39	23.88	25.74	2.17	2.96	3.26
20	50	Knifed	28.75	33.00	32.50	2.13	1.53	1.66	16.55	22.72	24.46	1.97	3.27	3.19
40	0	Broadcast	29.75	32.05	33.00	2.41	1.57	1.70	14.77	23.42	25.63	2.09	3.22	3.11
40	0	Knifed	30.75	31.75	33.00	2.46	1.62	1.85	16.20	21.98	23.30	2.15	4.94	3.60
40	25	Broadcast	30.25	31.75	33.00	2.51	1.67	1.87	16.94	23.94	24.49	2.09	3.12	3.07
40	25	Knifed	26.25	32.75	32.50	2.42	1.72	1.97	15.29	22.70	25.57	2.30	3.57	3.03
40	50	Broadcast	28.50	32.25	33.00	2.39	1.64	1.75	15.54	22.78	24.96	2.09	3.40	3.43
40	50	Knifed	34.00	32.75	33.50	2.75	1.69	1.83	15.11	21.73	23.09	2.57	5.14	3.97
80	0	Broadcast	31.75	32.25	32.75	2.71	1.91	2.08	17.81	24.46	24.64	2.49	4.62	3.58
80	0	Knifed	30.50	32.25	35.50	2.38	1.81	1.98	14.83	22.67	24.07	2.18	3.62	3.56
80	25	Broadcast	30.50	32.00	33.50	2.50	1.67	1.86	17.18	22.21	24.95	2.07	3.63	3.46
80	25	Knifed	32.75	32.50	34.00	2.56	1.73	1.89	13.44	23.01	26.12	2.24	3.73	3.13
80	50	Broadcast	27.00	33.25	32.25	2.35	2.00	2.14	19.39	25.77	27.12	1.92	3.01	2.83
80	50	Knifed	32.25	31.75	32.00	2.53	1.71	1.89	18.08	23.73	26.07	2.25	3.05	3.05

Table 19. F values as calculated by general linear models analysis for effects of P and K fertilizer and fertilizer placement on tissue macronutrient concentrations of alfalfa on a Newdale clay loam soil over 3 harvests (1989).

		N Concentration			P Concentration			K Concentration			S Concentration		
Source	DF	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
P	1	1.50	2.46	0.10	1.50	68.26*** [1]	62.64***	0.66	5.12*	4.44*	3.40	0.00	0.28
K	1	1.36	0.01	1.37	0.79	0.03	0.00	0.44	1.12	0.93	2.94	1.91	2.37
P^2	1	0.05	0.14	1.22	0.10	0.50	0.80	1.49	0.17	0.00	2.57	0.08	0.00
K^2	1	1.71	0.06	0.18	0.04	0.54	0.07	0.59	0.30	0.32	3.01	0.07	0.32
P x K	1	0.12	1.78	1.29	0.29	0.37	0.01	1.11	0.13	2.34	0.00	0.11	0.00
Placement	1	1.12	0.00	1.03	0.16	0.00	0.02	2.12	3.07	0.87	0.73	0.67	0.34
P x Placement	1	1.11	0.20	5.81*	0.18	2.92	1.77	1.53	0.84	0.05	0.85	0.82	0.01
K x Placement	1	1.51	0.42	1.73	0.03	0.01	0.05	1.48	0.23	0.39	3.22	0.82	0.26
CV		9.11	3.11	3.64	8.80	7.93	7.79	14.80	5.98	6.47	10.03	29.14	14.08

1 *, **, *** P values less than 0.05, 0.01 and 0.0001, respectively.

NOTE: Preliminary analysis was conducted and indicated highly significant differences due to harvest and data.

Table 20. Uptake of macronutrients (kg ha^{-1}) by alfalfa on a Newdale clay loam soil as influenced by method and rate of P and K fertilization (1989)

P	K	Placement	N uptake			P Uptake			K Uptake			S Uptake		
			Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
kg ha^{-1}														
0	0	Broadcast	33.73	29.20	21.72	2.59	1.34	1.04	18.08	20.67	15.64	2.43	3.43	2.16
0	0	Knifed	29.80	37.99	19.73	2.57	1.72	0.95	13.33	24.96	15.28	1.97	5.67	2.35
0	25	Broadcast	23.84	34.86	13.74	2.13	1.41	0.58	12.67	23.39	9.48	1.58	4.45	1.51
0	25	Knifed	33.35	39.64	29.03	2.46	1.96	1.51	23.70	30.26	21.87	2.42	3.80	2.67
0	50	Broadcast	38.61	34.48	22.07	3.07	1.52	1.01	20.54	25.49	15.47	2.70	3.80	2.09
0	50	Knifed	31.76	37.84	25.84	2.51	1.74	1.35	16.79	27.94	20.39	2.15	4.20	2.47
20	0	Broadcast	34.26	37.15	32.10	2.54	1.76	1.68	21.60	27.67	24.14	2.82	3.65	3.03
20	0	Knifed	39.16	49.67	35.04	3.03	2.43	1.70	16.99	37.86	26.09	2.84	5.14	3.55
20	25	Broadcast	32.16	31.23	36.38	2.88	1.46	1.89	15.63	21.36	28.79	2.22	3.76	3.90
20	25	Knifed	26.34	28.62	25.35	2.25	1.37	1.29	13.01	21.06	19.56	1.86	3.74	2.66
20	50	Broadcast	23.49	40.44	27.58	2.01	1.84	1.28	12.14	30.15	20.05	1.73	3.77	2.51
20	50	Knifed	40.15	50.76	36.11	2.89	2.36	1.88	24.48	35.02	27.26	2.81	5.04	3.51
40	0	Broadcast	36.43	35.15	24.87	2.96	1.72	1.28	18.59	25.73	19.63	2.58	3.53	2.34
40	0	Knifed	30.37	40.34	38.71	2.31	2.10	2.23	17.19	29.79	29.09	2.08	5.55	3.92
40	25	Broadcast	42.30	23.28	42.07	3.47	0.96	2.48	24.10	16.22	31.18	2.94	2.13	3.95
40	25	Knifed	34.57	46.32	39.85	3.06	2.51	2.43	20.12	33.15	31.77	2.91	5.14	3.72
40	50	Broadcast	29.99	48.41	39.60	2.48	2.48	2.12	16.76	34.48	30.52	2.16	5.06	4.07
40	50	Knifed	36.63	50.94	29.54	2.90	2.65	1.60	16.18	34.66	20.58	2.74	7.53	3.40
80	0	Broadcast	33.08	37.55	23.03	2.84	2.26	1.45	18.65	29.24	17.77	2.60	4.99	2.43
80	0	Knifed	27.69	39.23	32.30	2.13	2.19	1.80	12.83	27.35	21.83	2.02	4.32	3.26
80	25	Broadcast	26.96	40.96	42.29	2.21	2.14	2.34	15.21	28.39	31.55	1.83	4.56	4.37
80	25	Knifed	43.81	56.61	47.76	3.40	3.02	2.66	18.05	40.07	36.93	2.97	6.49	4.39
80	50	Broadcast	41.15	55.87	45.31	3.53	3.45	3.04	29.89	44.22	38.12	2.93	5.17	3.96
80	50	Knifed	36.52	53.60	46.05	2.86	2.87	2.71	20.47	39.98	37.44	2.55	5.14	4.38

Table 21. F values as calculated by general linear models analysis for effects of P and K fertilizer and fertilizer placement on uptake of macronutrients by alfalfa grown on a Newdale clay soil over 3 harvests (1989)

		N Uptake			P Uptake			K Uptake			S Uptake		
Source	DF	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
P	1	1.08	5.55*[1]	23.39***	1.60	15.73**	33.89***	0.68	5.30*	22.07***	1.32	3.07	20.37***
K	1	0.38	3.41	3.44	0.54	2.91	3.64	1.39	2.79	3.95*	0.07	0.48	2.07
P^2	1	0.22	0.00	4.30*	0.35	0.03	3.34	0.00	0.01	3.31	1.05	0.03	5.34*
K^2	1	0.17	1.66	1.64	0.02	2.20	1.55	0.10	1.95	1.49	0.32	1.35	1.46
P x K	1	0.01	1.70	4.30*	1.39	2.18	5.19*	1.72	1.54	6.25*	0.67	0.62	3.66
Placement	1	0.27	3.75	1.38	0.02	3.79	1.08	0.27	2.49	1.07	0.15	6.54*	1.90
P x Placement	1	0.01	0.00	0.01	0.05	0.27	0.22	1.50	0.11	0.07	0.00	0.02	0.00
K x Placement	1	0.99	0.18	0.77	0.32	0.29	0.59	0.80	0.23	0.45	1.78	0.03	0.75
CV		23.60	29.84	26.29	22.53	32.62	30.51	32.94	33.71	29.17	24.71	31.95	25.89

1 *, **, *** P values less than 0.05, 0.01 and 0.001, respectively.

Note: Preliminary analysis was conducted and showed highly significant differences due to harvest and site.

Table 22. Secondary and micronutrient concentration (mg g^{-1}) of alfalfa tissue on a Newdale clay loam soil as influenced by method and rate of P and K fertilization (1989)

P	K	Placement	Ca Concentration			Mg Concentration			Zn Concentration			Cu Concentration		
			Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
kg ha^{-1}														
0	0	Broadcast	18.64	15.08	15.77	4.38	6.06	4.77	0.0246	0.0398	0.0292	0.00476	0.00881	0.00746
0	0	Knifed	16.33	13.15	15.58	5.15	6.65	5.92	0.0262	0.0372	0.0304	0.00510	0.00840	0.00806
0	25	Broadcast	14.00	14.21	16.88	4.59	5.88	5.18	0.0252	0.0333	0.0301	0.00506	0.00821	0.00814
0	25	Knifed	16.69	17.08	19.11	3.17	5.35	4.76	0.0189	0.0342	0.0298	0.00439	0.00878	0.00911
0	50	Broadcast	16.49	16.19	17.15	4.62	5.14	4.46	0.0217	0.0374	0.0326	0.00446	0.00889	0.00821
0	50	Knifed	16.22	17.77	17.48	3.74	5.12	4.08	0.0208	0.0355	0.0291	0.00424	0.00848	0.00799
20	0	Broadcast	17.87	15.57	16.88	4.54	5.80	4.97	0.0278	0.0334	0.0302	0.00472	0.00806	0.00773
20	0	Knifed	17.99	15.36	17.16	5.48	5.59	4.92	0.0281	0.0349	0.0267	0.00491	0.00825	0.00682
20	25	Broadcast	14.69	14.58	16.60	4.57	5.61	4.80	0.0241	0.0313	0.0275	0.00472	0.00780	0.00686
20	25	Knifed	15.31	12.89	14.81	5.06	6.17	5.55	0.0263	0.0326	0.0276	0.00506	0.00754	0.00645
20	50	Broadcast	16.16	15.65	17.08	5.56	5.08	4.32	0.0261	0.0322	0.0253	0.00469	0.00750	0.00735
20	50	Knifed	15.63	17.56	18.52	4.09	5.35	4.08	0.0204	0.0326	0.0284	0.00450	0.00832	0.00960
40	0	Broadcast	15.53	15.87	14.71	5.19	4.87	4.43	0.0258	0.0273	0.0247	0.00488	0.00735	0.00578
40	0	Knifed	18.54	12.46	14.94	4.27	6.87	5.83	0.0285	0.0309	0.0281	0.00484	0.00791	0.00686
40	25	Broadcast	16.85	14.95	16.17	4.16	5.09	4.58	0.0228	0.0294	0.0268	0.00461	0.00750	0.00690
40	25	Knifed	18.46	16.12	16.30	5.34	6.14	4.82	0.0246	0.0342	0.0288	0.00480	0.00724	0.00645
40	50	Broadcast	15.30	14.34	16.55	4.84	5.36	5.04	0.0240	0.0312	0.0239	0.00491	0.00754	0.00592
40	50	Knifed	18.33	13.70	15.01	5.66	6.56	5.81	0.0317	0.0322	0.0268	0.00480	0.00739	0.00664
80	0	Broadcast	15.97	11.52	12.64	5.09	5.90	5.49	0.0271	0.0284	0.0239	0.00532	0.00664	0.00529
80	0	Knifed	17.73	15.49	18.40	4.30	5.45	5.04	0.0241	0.0324	0.0245	0.00476	0.00765	0.00608
80	25	Broadcast	15.71	15.22	15.28	3.88	5.84	4.94	0.0238	0.0300	0.0252	0.00465	0.00799	0.00604
80	25	Knifed	18.11	14.81	15.92	5.94	5.78	4.96	0.0249	0.0297	0.0269	0.00525	0.00074	0.00589
80	50	Broadcast	14.93	15.37	13.88	3.19	5.10	3.89	0.0203	0.0299	0.0232	0.00420	0.00728	0.00061
80	50	Knifed	16.59	16.87	15.79	4.55	5.04	4.24	0.0318	0.0299	0.0241	0.00476	0.00754	0.00562

Table 23. F values as calculated by general linear models analysis for effects of P and K fertilizer and fertilizer placement on tissue secondary and micronutrient concentrations of alfalfa on a Newdale clay loam soil over 3 harvests (1989)

		Ca Concentration			Mg Concentration			Zn Concentration			Cu Concentration		
Source	DF	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
P	1	0.17	0.72	6.35*[1]	0.04	0.14	0.07	1.68	30.20***	36.92***	0.85	18.87***	35.31***
K	1	4.44*	4.64*	1.04	0.51	3.65	3.74	1.80	0.62	0.48	5.99*	0.05	1.38
P^2	1	0.92	0.78	0.25	2.90	0.46	0.61	2.99	5.39*	2.25	0.26	5.58*	1.93
K^2	1	1.37	0.01	0.25	0.06	0.07	0.08	1.99	1.92	1.79	0.41	0.14	0.00
P x K	1	0.10	0.00	1.49	0.06	0.33	0.06	2.12	0.55	0.21	0.01	0.18	0.26
Placement	1	7.03*	0.57	2.14	0.35	1.44	1.66	0.90	1.26	1.24	0.09	0.28	1.16
P x placement	1	3.61	0.33	2.25	2.68	0.04	0.06	3.31	1.00	1.51	1.06	0.18	0.21
K x placement	1	0.10	0.58	0.57	0.00	0.00	0.11	0.95	0.48	0.06	0.01	0.20	0.06
CV		9.05	14.84	11.50	22.80	16.08	17.68	15.95	8.24	8.11	8.30	8.28	14.54

1 *, **, *** P values less than 0.05, 0.01 and 0.0001, respectively.

NOTE: Preliminary analysis was conducted and indicated highly significant differences due to harvest and site.

Table 24. Uptake of secondary and micronutrients (kg ha^{-1}) by alfalfa on a Newdale clay loam soil as influenced by method and rate of P and K fertilizer (1989).

P	K	Placement	Ca Uptake			Mg Uptake			Zn Uptake			Cu Uptake		
-kg ha^{-1}-			Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
0	0	Broadcast	20.10	13.74	9.55	4.96	5.46	2.99	0.0274	0.0359	0.0180	0.00527	0.00799	0.00451
0	0	Knifed	15.95	15.44	8.07	5.05	7.78	3.26	0.0258	0.0441	0.0172	0.00502	0.00994	0.00413
0	25	Broadcast	12.11	15.24	6.43	3.90	6.40	2.22	0.0218	0.0359	0.0122	0.00443	0.00885	0.00320
0	25	Knifed	21.35	19.88	15.44	3.68	6.69	4.17	0.0232	0.0410	0.0266	0.00555	0.01045	0.00786
0	50	Broadcast	22.52	18.33	10.77	6.51	5.80	3.02	0.0292	0.0422	0.0218	0.00587	0.01005	0.00520
0	50	Knifed	17.72	21.13	13.01	4.14	6.31	3.29	0.0227	0.0430	0.0228	0.00453	0.01015	0.00601
20	0	Broadcast	21.44	18.05	16.06	4.67	6.68	4.67	0.0313	0.0389	0.0295	0.00539	0.00942	0.00759
20	0	Knifed	21.95	23.36	17.95	6.79	8.66	5.21	0.0334	0.0582	0.0283	0.00578	0.01342	0.00714
20	25	Broadcast	17.05	14.22	17.01	5.34	5.41	5.35	0.0283	0.0302	0.0304	0.00540	0.00757	0.00715
20	25	Knifed	13.68	11.51	12.28	4.63	5.82	4.32	0.0238	0.0298	0.0229	0.00458	0.00690	0.00539
20	50	Broadcast	13.01	20.09	12.94	4.47	6.43	3.35	0.0210	0.0410	0.0195	0.00379	0.00957	0.00566
20	50	Knifed	22.82	26.94	19.74	5.36	8.27	5.31	0.0288	0.0503	0.0315	0.00635	0.01281	0.01103
40	0	Broadcast	19.34	17.43	11.40	6.32	5.35	3.30	0.0322	0.0300	0.0191	0.00600	0.00807	0.00452
40	0	Knifed	18.94	16.64	17.98	3.73	8.25	6.13	0.0251	0.0405	0.0335	0.00486	0.01036	0.00826
40	25	Broadcast	23.93	12.05	20.05	5.71	3.09	5.98	0.0319	0.0207	0.0335	0.00645	0.00614	0.00839
40	25	Knifed	23.59	22.29	19.61	6.58	8.67	5.82	0.0315	0.0479	0.0349	0.00614	0.01010	0.00779
40	50	Broadcast	16.12	21.55	19.47	5.11	7.97	5.92	0.0256	0.0473	0.0285	0.00531	0.01141	0.00699
40	50	Knifed	19.49	21.53	13.32	6.05	9.88	4.97	0.0356	0.0509	0.0232	0.00506	0.01170	0.00572
80	0	Broadcast	16.62	14.12	8.93	5.38	6.62	3.69	0.0289	0.0340	0.0167	0.10566	0.00797	0.00363
80	0	Knifed	16.40	19.28	17.22	4.05	6.57	4.51	0.0226	0.0390	0.0220	0.00438	0.00931	0.00570
80	25	Broadcast	13.87	19.84	19.17	3.41	7.37	6.26	0.0210	0.0384	0.0319	0.00410	0.01023	0.00761
80	25	Knifed	24.18	25.80	22.13	7.84	10.07	6.93	0.0334	0.0516	0.0378	0.00708	0.01286	0.00819
80	50	Broadcast	22.83	25.12	19.39	4.85	8.69	5.49	0.0320	0.0505	0.0329	0.00646	0.01208	0.00861
80	50	Knifed	18.79	28.58	22.50	5.16	8.50	6.12	0.0355	0.0504	0.0346	0.00539	0.01274	0.00799

Table 25. F values as calculated by general linear models analysis for effects of P and K fertilizer and fertilizer placement on uptake of secondary and micronutrients by alfalfa grown on a Newdale clay loam soil over 3 harvests (1989).

		Ca Uptake			Mg Uptake			Zn Uptake			Cu Uptake		
Source	DF	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3	Harvest 1	Harvest 2	Harvest 3
P	1	0.13	3.06	12.65**[1]	0.30	3.99*	21.59***	2.19	0.46	7.18**	0.90	0.93	1.87
K	1	0.03	5.68*	3.03	0.02	0.99	1.25	0.05	1.86	1.82	0.02	2.07	2.84
P^2	1	0.51	0.10	3.99*	1.42	0.04	8.18**	2.27	0.11	3.43	0.38	0.10	2.53
K^2	1	0.03	1.45	1.18	0.00	1.29	3.60	0.78	3.02	2.44	0.16	1.81	0.49
P x K	1	0.62	0.86	1.69	0.06	2.16	3.25	3.70	1.40	2.52	0.84	1.11	1.02
Placement	1	0.79	3.54	2.77	0.19	8.01**	3.70	0.25	4.84*	2.23	0.02	3.46	2.03
P x Placement	1	0.10	0.13	0.24	1.46	0.00	0.00	0.89	0.00	0.01	0.00	0.00	0.24
K x Placement	1	0.35	0.00	0.46	0.10	0.23	0.58	2.40	0.56	0.14	0.43	0.32	0.01
CV		27.33	34.47	31.55	31.69	27.90	25.08	22.42	31.02	30.46	21.95	32.36	37.30

1 *, **, *** P values less than 0.05, 0.01, 0.0001, respectively.

NOTE: Preliminary analysis was conducted and showed highly significant differences due to harvest and site.