CORD IV Project
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Evaluation of forage varieties for tolerance to management stress.

Final Report to Ontario Forage Council

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EXECUTIVE SUMMARY

Forages are a primary feed source for many classes of animals in the province, including, but not limited to, dairy, beef, sheep, and equine. Although each of these sectors have different constraints and opportunities, a common theme is a desire to use plant varieties that are best suited to the production system. This is to ensure stability of feed production and to reduce costs of their production, harvest, and storage. This research project was designed to provide a systematic evaluation of commercially available alfalfa varieties in Ontario for specific attributes, namely, tolerance to machine traffic, tolerance to liquid manure application, and stem physical characteristics in hay systems. Since these characteristics are subject to genotype by environment interaction, assessment under Ontario conditions was necessary to provide relative variety performance within the province.

Herbage yield of 49 varieties of alfalfa managed under a standard, 3-harvest system, were obtained from trials conducted at Elora, Enniskillen, and New Liskeard. Yield results were incorporated into the Ontario Forage Crops Committee performance database and computations of relative variety performance for Ontario. Maturity and stem diameter measures were also recorded from the trials at Elora and Enniskillen; for stem diameter measurement, diameters of Stage 4 stems (late bud stage, >2 buds with open flowers) were measured to avoid confounding effects due to maturity differences among stems. For both traits, variety differences were detected. There were no significant variety x environment interactions found for mean stage by weight and for stem diameter. This indicated that relative maturity and stem diameter were consistent from test to test, harvest to harvest, and that the data could be pooled.

Combined over all trials, nine varieties (53V52, Amerigraze 401+Z, Approved, Dominion, Guardsman II, Jolt, Macon, Marquis, and Reliance) were significantly less mature than the test mean, and five varieties (Enhancer, Forecast 1001, Satellite, Stallion, and Starbuck) were significantly more mature than the test mean. Five varieties (54V54, Affinity+Z, Amerigraze 401+Z, Pickseed 2065MF, and Reliance) had Stage 4 stems that were significantly smaller in diameter compared to the test mean. Three varieties (134, Magnum IV, and WinterGold) had Stage 4 stems that were significantly larger in diameter compared to the test mean.

Herbage yield, maturity, and Stage 4 stem diameter were not correlated with each other. The absence of a strong correlation indicated that if maturity and/or stem diameter was an issue for producers, then both management (ie. harvest timing) and variety selection are factors to incorporate in the design of a system to produce the desired harvested product. For example, harvesting at an earlier stage of development will result in forage that has a greater proportion of finer stemmed, less mature material. However, varieties differ in their maturity as well as their diameter of Stage 4 stems. Thus, one could leave harvest date unchanged but modify the maturity/diameter by changing the variety. Since there was not a high correlation with herbage yield, the latter does not need to be sacrificed to obtain the desired forage characteristics. Bi-plots were constructed to assist in identifying varieties with the desired combination of attributes.

There were differences among varieties in their response to the application of traffic and liquid manure (4500 gal/acre) after first and second harvest, either with or without soil aeration. Differences among treatments became more pronounced as the stand aged. Traffic stress reduced yield in the second year by 5% and decreased yield in the third year over 9%. Over the three years, the average reduction in yield due to traffic stress was 5.2% averaged over all varieties. The reaction varied among varieties, some showing no change in yield and others having reductions in yield as high as 13%.

Two applications of 4500 gal/acre liquid manure in each of the years led to an increase in yield for all varieties. The average increase over the three year period was 14.5%. The greatest yield increase was detected in 2007. This was a particularly dry season but in a related study which included a water treatment (Bowman, 2009), this manure response was due to the nutrients not the water per se. There were also interactions with variety as some varieties showed greater response and others showed lower than average response to the manure application; increases ranged from 2.4 to 27.4% among the varieties over the three year period.

Aeration in combination with liquid manure also resulted in higher seasonal yields but not as high when the manure was applied without the aeration treatment. In general, there was a positive correlation between herbage yield of the control treatment and yield under the various stresses (r ranged from 0.54 to 0.59, P=0.0001). However, the correlation was not tight as there were interactions in the responses of the varieties to either traffic or manure stress treatments. Some varieties were very sensitive to traffic (eg. 53V52) while others were relatively unaffected by traffic (eg. AC Brador). Similarly, some varieties were highly responsive to manure application (eg. Reliance) while others were not as responsive to the manure application (eg. Jolt). There were also differences in their reaction to the aeration treatment. Again, some varieties were unaffected by the aeration treatment in conjunction with the manure application (eg. Genoa) while others had sizable declines in yield when aeration was used (eg. Gold Plus MF).

Incorporation of liquid manure into an alfalfa production system is of benefit for forage yield production. All varieties showed a numerical yield increase under the 4500 gal/acre biannual treatment application. For producers, this provides for two additional times of the year (late May/early June and Mid-late July) for application/disposal of liquid manure for livestock farms. These application times may also have less nutrient losses compared to late fall or late winter applications. However, the impact of these applications of liquid manure on the nutritional composition of the feed and changes in the soil system also need to be assessed.

BACKGROUND

Forages are a primary feed source for many classes of animals in the province, including, but not limited to, dairy, beef, sheep, and equine. Each of these sectors have different constraints and opportunities. A common theme is the desire to use plant varieties and species mixtures that are best suited to the production system. This ensures stability of feed production and reduced costs of their production, harvest, and storage.

In past years, yield performance assessment has been conducted on forage varieties through a cooperative testing arrangement within the umbrella of the Ontario Forage Crops Committee (a sub-committee of the OASCC Field Crop Research and Service Committee). This evaluation was conducted at specific sites with forage yield under a standardized testing protocol (2002 Variety Testing Procedures, Ontario Forage Crops Committee). This protocol was designed to obtain relative yield information under management conditions that would provide maximal yield potential. This information was supplemented with laboratory assessments of disease and pest reaction to provide guidance to producers for selecting varieties (2005 Variety Performance, Ontario Forage Crops Committee). It was recognized that pest reaction was not subject to genotype x environment interaction so evaluations of these attributes in laboratories within or outside of Ontario/Canada could be used to provide this information. On the other hand, yield and persistence were highly subject to genotype x environment interaction, thus there was a need to obtain this data from fields in Ontario was necessary (Variety Testing Procedures, Ontario Forage Crops Committee). These testing protocols have been recognized by the Variety Registration Office, Canadian Food Inspection Agency, and have been accepted protocols for determination of merit for registration of new varieties for sale in Canada.

Reductions in public research effort in Ontario, both Federal and Provincial, have reduced the extent of the evaluation. For forages, Federal stations are no longer involved, and a number of the Provincial research sites, now managed by the University of Guelph, have either terminated or have significantly lower levels of activity. Nonetheless, third-party variety performance information is still identified as a high priority among forage producers in the province (Ontario Forage Council priorities; OFCC priorities; FCRSC research priorities).

Concurrently, there is a desire for additional varietal information, especially for hay quality characters and relative performance under management system that are less than ideal. This research project was designed to provide a systematic evaluation of commercially available forage varieties in Ontario for specific attributes, namely, tolerance to machine traffic, tolerance to liquid manure application, and stem physical characteristics in hay systems. These characteristics are subject to genotype x environment interaction thus assessment within the province is necessary to provide relative variety performance.

Studies conducted at the University of Wisconsin have indicated that alfalfa yield is depressed due to traffic injury caused by a mechanical harvesting system. A comparison of a silage system (traffic one day after cutting) and a hay system (traffic five days after cutting) revealed that the hay traffic resulted in significant reductions in forage yield and that there were differences among alfalfa varieties to this stress. At the Elora site in 2003, a comparison of varieties and forage species was conducted by S.R. Bowley's research group to determine if there were species and variety differences in tolerance of traffic injury five days following cutting. This "hay traffic" stress was imposed on a series of OFCC trials following first harvest in 2003. For each test, five days after cutting, two replicates were driven on with a John Deere 6420, two replicates were not. This stress was applied to alfalfa (6 tests involving 95 varieties), orchardgrass (7 varieties), timothy (10 varieties), reedcanary (4 varieties), tall fescue (7 varieties), and red clover (8 varieties). On average, the reduction in yield in alfalfa and red clover was 11 and 13%, respectively. Surprisingly, the reduction in second cut yields were significantly greater for the grasses, the yield reduction for tall fescue, orchardgrass, reed canary, and timothy averaged 15%, 16%, 27% and 32%, respectively. Variety differences were also detected in their tolerance to the stress, the range in reduction for alfalfa was 0 to 25%. It was predicted that varieties with more rapid regrowth, higher yield potential would be most susceptible to this traffic injury. However, there was no relationship between yield performance and the susceptibility to traffic injury. This preliminary, one-year study has revealed that there is a significant loss in yield in areas that are driven upon during hay harvest, grasses were more susceptible to the stress, and that there are varieties that have greater tolerance, and varieties that have lower tolerance to this stress. Assessment of the genotype x environment interaction will be necessary in order to determine the stability of the assessment and provide relative performance information to producers.

S.R. Bowley's group at the University of Guelph In collaboration with Nuhn Industries, Sebringville, ON and Precision Metal Fabricating, Rosetown SK, a research size soil aerator was modified to allow precision application of liquid manure to research plots. Through a project financially supported by the OFC & AAC, this unit was used in 2004 at the Elora research station to study the effects of soil aeration and liquid manure application to an alfalfa-timothy mixture. In this study, the effects of aeration, manure rate (3000, 4500, 6000 gal/acre), day of application following harvest (2,4,6 days after harvest), and study of the effects following first and following second harvest were measured. This study indicated that the negative effects of the aerator per se could be reduced if it was used close to harvest. The average subsequent yield reduction due to aeration (averaged over all treatments) was 2% if applied 2 days after cutting, 7% if applied 4 days after cutting, and 9 % if applied 6 days after cutting. Without aeration, the optimum level of manure application (based on subsequent regrowth yield) was 4500 gal/acre. However, if aeration was included, the optimum level was higher, at least 6000 gal/acre. Additional seasons of application will be made to confirm the response, reaction findings, and assess the level of variety x manure application.

MATERIALS AND METHODS

Alfalfa varieties: Yield, maturity and stem diameter.

Trials were seeded in 2005 at three sites in Ontario, one at the University of Guelph Elora Research Station, the second on a private farm site located near Enniskillen, and the third at the University of Guelph New Liskeard Station. Forty-nine varieties of alfalfa were seeded. The test was arranged as a simple lattice repeated with two replications and two repetitions. Plot size was 1 x 6 m, seeding rate of 13 kg/ha. Trial management corresponded to the Ontario Forage Crop Committee (OFCC) Standard Test Protocols. In 2005, trials were clipped and forage removed early August. Fertilizer was applied in early September as per soil test.

In 2006, 2007, and 2008, three yield harvests were taken for the Elora and Enniskillen trials, two harvests for the New Liskeard trial. A Haldrup self-propelled sickle bar forage harvester was used at Elora and a Carter self-propelled sickle bar forage harvester used at Enniskillen. In 2007, severe drought at the Eniskillen site prevented the use of regrowth yields collected for that test in 2007. Herbage dry matter yields were computed for each plot and yields of each harvest and total seasonal yields were subjected to variance analyses with a lattice model using the Proc Mixed procedure of SAS.

Prior to harvest, a 9 dm^2 hand clipped sample was removed from two replications in Elora and Enniskillen. The samples were fractionated into maturity classes and the Mean Stage by Weight (MSW) maturity computed as per the method of Kalu and Fick (1981). The stem diameter of the first full internode above the cut end was measured for all Stage 4 stems using electronic calipers. Stage 4 corresponds to the late bud stage (>2 floral buds with no open flowers). MSW and stem diameter measures were subjected to Proc Mixed variance analyses for individual harvests as well as combined analyses over harvests and locations. Correlations and graphical analyses were used to elucidate relationships and genotype interactions. A Type 1 error rate of 0.05 was set for all statistical comparisons.

Alfalfa Varieties: Manure, Traffic, and Aeration

In 2005, plots of 49 varieties of alfalfa were seeded at the Elora Research Station. The trial arrangement was a split-plot with entries allocated using a balanced lattice randomization. Plot size was 1 x 6 m and alfalfa was seeded at 13 kg/ha. Four treatments, Control, Traffic, Manure, and Manure-Aeration, were the main plots, alfalfa varieties the sub-plot. Treatments were applied after the first and second harvests in 2006, 2007, and 2008. The experiment had two replications. The Control treatment was the standard variety trial management practice as per the OFCC Standard Test protocol. Annual P_2O_5 & K_2O applications were based on soil tests for each treatment regime. The Traffic treatment was applied 3 days after each harvest by systematically driving across the plots using a tractor (John Deere 7000 series with standard tires) so that the entire plot received a single wheel pass over the entire surface. The Manure treatment was 4500 gal/acre liquid dairy manure (obtained from the Elora Dairy Research Facility) and applied using a custom built aerator-precision manure applicator (Nuhn Industries, Sebringville, ON and Precision Metal Fabricating, Rosetown SK) that was mounted on a three-point hitch on a John Deere 7000 series tractor (Figure 1). The custom built unit was equipped with a 500 gallon tank and was designed to operate in any combination of aeration, manure, or aeration + manure treatment mode. Manure was applied with drop-tubes with fan nozzles positioned behind the aeration unit. The aerator is part of the Smart Till product line from HCC Inc. (Hart-Carter Company Inc.), Mendota, Illinois. The Manure + Aeration treatment was 4500 gal/acre of liquid manure along with aeration. The aerator was operated at an angle of 2°.

In each of the three years, three yield harvests were taken for each test using a Haldrup self-propelled sickle bar forage harvester. Herbage dry matter yields were computed for each plot and yields of each harvest and total seasonal yields were subjected to variance analyses using the Proc Mixed procedure of SAS. Yield of the first harvest in 2006 (prior to treatment effects) was used as a covariate.

Seeding rate effects on Yield, maturity and stem diameter

Trials were seeded in 2006 at two sites in Ontario, one at the University of Guelph Elora Research Station, the second on a private farm site located near Enniskillen. Five varieties of alfalfa were seeded at four seeding rates (5.5, 11, 16.6, and 22 kg/ha). The test was arranged as a randomized complete block with four replications. Plot size was 1 x 6 m. Trial management corresponded to the Ontario Forage Crop Committee (OFCC) Standard Test Protocols. In 2006, trials were clipped and forage removed early August. Fertilizer was applied in early September as per soil test.

In 2007 and 2008 three yield harvests were taken for the trials. A Haldrup self-propelled sickle bar forage harvester was used at Elora and a Carter self-propelled sickle bar forage harvester used at Enniskillen. Herbage dry matter yields were computed for each plot and yields of each harvest and total seasonal yields were subjected to variance analyses using the Proc Mixed procedure of SAS.

Prior to harvest, a 9 dm^2 hand clipped sample was removed from two replications in Elora and Enniskillen. The samples were fractionated into maturity classes and the Mean Stage by Weight (MSW) maturity computed as per the method of Kalu and Fick (1981). The stem diameter of the first full internode above the cut end was measured for all Stage 4 stems using electronic calipers. Stage 4 corresponds to the late bud stage (>2 floral buds with no open flowers). At the Enniskillen site, the total number of stems per sample were also recorded. MSW, stem diameter, and stem density (number per ft^2) were subjected to Proc Mixed variance analyses for individual harvests as well as combined analyses over harvests and locations. Means were compared pairwise using Tukey’s adjustment as well as via regression response over seeding rate. A Type 1 error rate of 0.05 was set for all statistical comparisons.

Figure 1. Photos of custom-built aeration-liquid manure application unit. 1A. Refill of the manure reservoir tank. 1B. View from side showing the agitator, metering unit and aerator. 1C, 1D. View of plots immediately following the aeration + manure treatment.

RESULTS

Variety yield performance

Herbage yield was analyzed and the results for the standard management tests at Elora (2006, 2007, and 2008), Enniskillen (2006 and 2008), and New Liskeard (2006, 2007, 2008) were included in the OFCC variety trial database. Due to the drought for second and third harvests at Enniskillen, there was insufficient yield data in 2007 to include this test-year in the OFCC database. Yield summaries for total seasonal herbage yield are summarized for first production year yields (Table 1), second production year yields (Table 2) and third production year yields (Table 3).

Maturity

Genotype differences were detected but there were no genotype by location/year differences detected. Table 4 provides the summary for first harvest (five location-years), and the summary for season weighted MSW (four location-years). The season weighted MSW was computed as the average MSW at each harvest weighted by the herbage yield for the harvest. Season weighted MSW is a measure of the average maturity of all material removed from the plot that season. The varieties in Table 4 have been sorted based on the average MSW across trials, the least mature are at the top and most mature are at the bottom of the list.

At first harvest in 2006, the Elora trial was at a later stage of maturity than the Enniskillen test (trial MSW 3.4 vs 2.9, respectively) but the situation was reversed the following year (trial MSW 3.7 vs 4.6, respectively). Relative maturity ratings of varieties were consistent from trial to trial and cut to cut. First harvest MSW was correlated with the season weighted MSW ($r=0.76$, $P=0.0001$).

Combined over trials, the season weighted MSW of the varieties ranged from 3.1 to 3.7. Nine varieties (53V52, Amerigraze 401+Z, Approved, Dominion, Guardsman II, Jolt, Macon, Marquis, and Reliance) were significantly less mature than the test mean and five varieties (Enhancer, Forecast 1001, Satellite, Stallion, and Starbuck) were significantly more mature than the test mean.

Stem Diameter

There were genotype differences for stem diameter of Stage 4 stems, however, there were no genotype by harvest, or genotype x location differences detected. Thus, the data across trials and harvests could be pooled. Table 5 presents the stem diameter means pooled over harvests and tests. Varieties are sorted in Table 5 from thin stems (top of list) to thicker stems (bottom of list).

Five varieties (54V54, Affinity+Z, Amerigraze 401+Z, Pickseed 2065MF, and Reliance) had Stage 4 stems that were significantly smaller in diameter compared to the test mean. Three varieties (134, Magnum IV, and WinterGold) had Stage 4 stems that were significantly larger in diameter compared to the test mean.

Table 1. First production year herbage yield of 49 alfalfa varieties seeded 2005 at three sites in Ontario and harvested three times in 2006 under a standard yield test management regime. Design was a simple lattice repeated with two replicates and two replications.

		Total herbage yield (DM T / ha)			Yield as % of test mean			
Code	Variety	Elora	Enniskillen	New Liskeard	Elora	Enniskillen	New Liskeard	Average
1498	134	12.4	13.1	11.1	102.8	107.1	96.6	102.2
1613	53V52	11.7	13.4	11.0	97.2	109.8	95.9	101.0
1584	54H91	11.6	11.2	11.4	96.1	91.1	98.7	95.3
1582	54V46	11.9	12.9	12.9	98.4	105.4	111.9	105.2
1419	54V54	12.3	12.9	11.8	101.5	105.4	102.2	103.0
1486	AC Brador	11.7	12.6	11.8	96.9	103.2	103.0	101.1
1409	Affinity+Z	11.2	12.3	11.4	92.6	100.6	99.4	97.5
1392	Amerigraze 401+Z	12.9	12.0	11.3	106.7	97.7	97.9	100.8
1416	Apex	11.4	12.2	11.5	94.4	99.5	99.6	97.8
1481	Approved	11.4	13.9	11.1	94.0	113.2	96.9	101.4
1579	Ascend	12.0	13.5	12.5	99.0	110.3	108.8	106.1
1294	Dominion	12.9	11.0	11.3	106.7	89.8	98.7	98.4
1471	Enhancer	12.8	12.4	12.0	105.5	101.2	104.4	103.7
1586	Exp586	11.8	13.1	10.8	98.0	107.3	94.1	99.8
1610	Exp610	12.3	11.9	12.2	101.7	97.1	106.2	101.7
1624	Exp624	12.1	12.1	11.2	100.5	99.1	97.1	98.9
1635	Exp635	11.6	11.5	11.6	96.0	94.2	101.1	97.1
1525	Forecast 1001	12.1	12.0	12.3	99.8	97.9	106.8	101.5
1601	FSG 300LH	11.9	11.8	9.5	98.9	96.3	82.5	92.6
1474	Geneva	11.9	12.6	11.1	98.8	103.1	96.5	99.5
1607	Genoa	12.4	13.1	12.4	102.5	106.7	107.9	105.7
1609	GH700	11.9	12.6	11.6	98.7	102.6	100.8	100.7
1388	Gold Plus MF	11.8	12.8	10.8	97.3	104.7	93.9	98.7
1402	Grazemaster	12.3	12.2	11.2	101.9	100.1	97.3	99.8
1633	Guardsman II	11.2	11.0	11.6	92.3	89.6	101.3	94.4
1524	Hybri-Force 400	12.1	13.6	11.1	99.9	111.0	96.5	102.5
1411	Jolt	12.2	12.8	11.0	101.1	104.4	95.3	100.3
1527	Macon	12.4	11.7	11.3	102.9	95.8	98.6	99.1
1521	Magnum III-Wet	12.9	13.2	11.6	106.7	107.7	100.5	104.9
1325	Magnum IV	12.7	11.9	10.8	104.9	97.1	94.2	98.8
1479	Marquis	11.6	12.5	10.7	95.9	102.2	93.4	97.2
1541	Multiplier 3	11.4	12.2	12.5	94.1	99.5	108.4	100.7
1432	OAC Superior	12.4	13.4	11.5	102.8	109.8	100.2	104.3
9041	Exp9041	12.9	11.4	12.0	106.9	93.0	104.5	101.5
1504	Pickseed 2065MF	12.4	12.9	11.5	102.9	105.5	99.6	102.7
1448	Pickseed 8925MF	12.0	11.3	11.6	98.9	92.2	100.9	97.3
1636	Radar	12.2	12.8	12.6	100.9	104.7	109.7	105.1
1535	Reliance	11.8	14.1	11.3	97.4	114.9	98.2	103.5
1462	Rhino	11.7	11.2	11.9	97.0	91.1	103.3	97.2
1600	Satellite	12.1	12.5	12.0	100.0	102.1	104.0	102.0
1410	Stallion	12.3	12.7	12.0	101.9	103.5	104.7	103.3
1577	Starbuck	11.7	13.0	11.9	97.1	106.4	103.1	102.2
1580	Steak	12.0	12.2	12.2	99.2	99.8	105.7	101.6
1615	Stealth SF	12.4	13.1	10.7	102.4	107.1	92.8	100.8
1073	Surpass	12.9	12.7	9.9	106.3	103.8	85.9	98.7
1537	Valiant	12.1	13.1	11.3	99.8	106.7	98.2	101.6
1482	Wintergold	11.8	12.3	11.1	97.3	100.7	96.4	98.1
1599	WL 319HQ	11.9	13.1	10.2	98.5	106.9	88.4	98.0
1512	WL 327	12.9	12.4	11.1	107.1	101.3	96.8	101.7
se		0.54	0.50	1.4				
mean		12.1	12.2	11.5				
CV (%)		6.3	6.3	8.0				

Table 2. Second production year herbage yield of 49 alfalfa varieties seeded 2005 at three sites in Ontario and harvested three times in 2007 under a standard yield test management regime. Design was a simple lattice repeated with two replicates and two replications. The Enniskillen site was not included due to severe drought during second growth.

		Total herbage yield (DM T / ha)		Yield as % of test mean		
Code	Variety	Elora	New Liskeard	Elora	New Liskeard	Average
1498	134	10.3	10.7	108.1	99.3	103.7
1613	53V52	9.2	10.9	96.2	101.1	98.6
1584	54H91	9.2	10.7	96.6	99.3	97.9
1582	54V46	10.5	11.4	110.3	105.5	107.9
1419	54V54	9.6	10.3	100.9	95.4	98.2
1486	AC Brador	9.0	10.7	94.3	98.7	96.5
1409	Affinity+Z	9.2	10.7	96.1	98.8	97.5
1392	Amerigraze 401+Z	10.6	10.4	111.5	95.7	103.6
1416	Apex	9.0	10.5	94.7	96.7	95.7
1481	Approved	8.8	10.0	92.7	92.2	92.4
1579	Ascend	10.2	11.1	107.4	102.2	104.8
1294	Dominion	9.4	10.8	98.2	99.7	98.9
1471	Enhancer	9.6	11.4	100.7	105.3	103.0
1586	Exp586	9.8	10.8	102.8	99.8	101.3
1610	Exp610	9.9	10.8	104.1	99.9	102.0
1624	Exp624	10.2	10.9	106.7	100.7	103.7
1635	Exp635	10.0	10.5	105.1	97.0	101.0
1525	Forecast 1001	10.1	10.9	106.1	100.6	103.4
1601	FSG 300LH	9.4	10.7	98.6	98.4	98.5
1474	Geneva	10.3	10.6	107.6	97.5	102.6
1607	Genoa	10.4	11.3	109.1	104.8	106.9
1609	GH700	10.4	11.4	108.6	104.9	106.8
1388	Gold Plus MF	9.4	11.5	98.8	106.1	102.4
1402	Grazemaster	9.8	10.7	102.3	98.5	100.4
1633	Guardsman II	9.3	10.7	97.7	98.6	98.2
1524	Hybri-Force 400	9.4	10.5	98.7	97.0	97.9
1411	Jolt	9.2	10.9	96.3	100.9	98.6
1527	Macon	9.9	10.5	104.1	96.8	100.4
1521	Magnum III-Wet	10.7	10.9	112.6	101.0	106.8
1325	Magnum IV	9.7	10.8	101.2	99.5	100.3
1479	Marquis	8.4	10.3	88.4	95.0	91.7
1541	Multiplier 3	8.7	10.4	91.7	96.4	94.0
1432	OAC Superior	10.4	11.2	108.7	103.7	106.2
9041	Exp9041	9.8	10.0	102.8	92.7	97.7
1504	Pickseed 2065MF	10.0	11.1	104.3	102.2	103.2
1448	Pickseed 8925MF	8.9	10.6	92.8	98.4	95.6
1636	Radar	8.5	11.7	89.3	108.2	98.8
1535	Reliance	9.6	10.7	100.8	98.9	99.9
1462	Rhino	9.4	10.3	98.8	95.2	97.0
1600	Satellite	10.4	11.3	109.4	104.4	106.9
1410	Stallion	9.8	10.9	102.6	100.4	101.5
1577	Starbuck	10.0	10.9	105.3	101.0	103.1
1580	Steak	9.5	10.7	99.9	99.0	99.5
1615	Stealth SF	10.7	11.9	112.3	109.6	110.9
1073	Surpass	10.4	10.8	108.8	99.8	104.3
1537	Valiant	10.2	11.4	106.9	105.4	106.2
1482	Wintergold	9.8	10.8	102.2	100.2	101.2
1599	WL 319HQ	9.5	10.8	99.2	99.5	99.4
1512	WL 327	10.3	10.6	108.0	98.1	103.1
mean		9.5	10.8			
CV (%)		6.3	5.3			

Table 3. Third production year herbage yield of 49 alfalfa varieties seeded 2005 at three sites in Ontario and harvested three times in 2008 under a standard yield test management regime. Design was a simple lattice repeated with two replicates and two replications.

		Total herbage yield (DM T / ha)			Yield as % of test mean			
Code	Variety	Elora	Enniskillen	New Liskeard	Elora	Enniskillen	New Liskeard	Average
1498	134	11.3	9.5	11.7	109.3	96.8	101.9	102.7
1613	53V52	10.2	9.5	11.0	99.2	96.8	95.5	97.1
1584	54H91	10.0	9.1	11.8	97.0	92.4	102.6	97.3
1582	54V46	11.0	10.2	11.0	107.1	103.7	95.6	102.2
1419	54V54	10.0	10.2	11.1	96.7	103.0	96.8	98.8
1486	AC Brador	9.4	9.3	11.1	91.6	93.9	96.4	94.0
1409	Affinity+Z	9.6	9.4	12.0	92.9	95.7	104.1	97.6
1392	Amerigraze 401+Z	10.4	10.2	12.0	101.0	103.0	104.1	102.7
1416	Apex	10.0	10.0	11.5	97.1	101.4	100.1	99.6
1481	Approved	9.5	9.6	11.5	91.9	97.0	99.8	96.3
1579	Ascend	11.1	10.3	11.7	107.4	104.1	101.6	104.4
1294	Dominion	9.4	9.3	12.4	90.8	94.4	107.9	97.7
1471	Enhancer	11.0	9.7	10.6	107.0	98.8	92.4	99.4
1586	Exp586	9.4	10.6	10.9	91.1	107.5	95.1	97.9
1610	Exp610	10.7	9.4	11.4	103.7	95.2	99.0	99.3
1624	Exp624	11.5	10.2	10.7	111.1	103.7	92.8	102.5
1635	Exp635	10.9	9.8	11.1	105.6	99.4	96.6	100.5
1525	Forecast 1001	10.3	10.0	11.8	99.5	101.4	102.2	101.0
1601	FSG 300LH	9.6	9.5	12.3	93.5	96.0	107.0	98.8
1474	Geneva	10.7	10.3	10.8	103.4	104.0	94.1	100.5
1607	Genoa	11.1	10.7	11.3	107.8	108.2	98.2	104.7
1609	GH700	10.6	10.0	12.4	102.8	101.3	107.7	103.9
1388	Gold Plus MF	10.1	9.6	12.3	97.6	97.9	106.9	100.8
1402	Grazemaster	10.9	9.8	11.1	105.8	99.5	96.1	100.5
1633	Guardsman II	9.8	9.9	10.9	94.9	100.6	95.2	96.9
1524	Hybri-Force 400	11.0	10.9	10.6	106.7	110.9	92.4	103.3
1411	Jolt	10.0	9.5	11.3	97.0	96.0	98.7	97.2
1527	Macon	9.6	10.4	12.9	92.8	105.7	112.0	103.5
1521	Magnum III-Wet	10.5	10.3	11.1	101.5	104.5	96.7	100.9
1325	Magnum IV	10.8	8.6	11.6	104.5	86.9	101.0	97.5
1479	Marquis	8.9	9.7	11.6	86.6	98.5	100.5	95.2
1541	Multiplier 3	8.4	9.7	11.4	81.3	98.6	99.5	93.1
1432	OAC Superior	10.7	10.4	11.6	103.8	106.0	101.0	103.6
9041	Exp9041	9.6	9.7	12.3	93.6	98.5	106.6	99.6
1504	Pickseed 2065MF	10.9	10.4	11.7	105.3	105.5	102.2	104.3
1448	Pickseed 8925MF	9.2	8.5	11.4	89.4	85.8	99.5	91.6
1636	Radar	10.5	9.8	10.5	102.0	99.5	91.1	97.5
1535	Reliance	10.4	10.2	11.1	100.7	103.2	96.9	100.3
1462	Rhino	10.1	9.8	10.9	98.4	99.5	94.5	97.5
1600	Satellite	10.7	10.3	11.8	103.5	104.4	102.8	103.6
1410	Stallion	10.6	9.5	11.7	103.3	96.7	102.1	100.7
1577	Starbuck	10.3	9.5	12.2	99.6	95.9	105.9	100.5
1580	Steak	9.6	9.5	12.3	92.6	96.6	106.7	98.6
1615	Stealth SF	11.7	10.4	10.6	113.4	105.3	92.1	103.6
1073	Surpass	11.2	9.5	12.0	109.1	96.7	104.3	103.3
1537	Valiant	10.9	9.9	11.7	105.8	100.2	101.6	102.5
1482	Wintergold	10.2	10.1	11.7	99.3	102.2	101.6	101.0
1599	WL 319HQ	10.5	10.6	12.0	102.2	107.3	104.5	104.7
1512	WL 327	10.5	9.8	11.6	101.8	99.8	101.2	100.9
se		0.40	0.47	0.5				
mean		10.3	9.9	11.5				
CV (%)		6.3	6.3	8.8				

Table 4. Mean stage by weight (MSW) of 49 alfalfa varieties seeded in 2005 at Elora and Enniskillen and harvested three times in 2006, 2007 and 2008.
Design was a simple lattice repeated with two replications and two repetitions. Table sorted based on season weighted MSW.

	Harvest 1, MSW							Season weighted MSW						
		Maturity index	2006		2007		2008		Maturity index		2006		2007	2008
Variety	Mean	relative to mean	Elora	Enniskillen	Elora	Enniskillen	Enniskillen	Mean	relative to mean		Elora	Enniskillen	Elora	Enniskillen
53V52	3.7	0.0	3.3	2.9	3.7	4.7	4.1	3.1	-0.29	*	3.3	3.0	3.4	2.6
Marquis	3.5	-0.2	3.0	3.1	3.4	4.8	3.7	3.1	-0.26	*	3.0	3.1	3.2	3.2
Amerigraze 401+Z	3.6	-0.2	3.1	2.6	3.4	4.5	4.1	3.1	-0.26	*	3.1	2.6	3.3	3.4
Jolt	3.5	-0.2	3.5	2.7	3.7	4.5	3.5	3.1	-0.24	*	3.5	3.0	3.7	3.2
Dominion	3.5	-0.2	3.5	3.5	3.3	4.2	3.6	3.2	-0.22	*	3.4	3.1	3.3	3.3
Approved	3.5	-0.3	3.4	2.6	3.7	3.7	3.9	3.2	-0.20	*	3.2	2.8	3.4	3.3
Macon	3.5	-0.2	3.5	2.6	3.3	4.6	3.4	3.2	-0.20	*	3.2	2.5	3.2	3.4
Guardsman II	3.7	-0.1	3.5	3.0	3.7	4.7	4.3	3.2	-0.19	*	3.5	3.3	3.5	3.8
Reliance	3.5	-0.2	4.1	3.3	3.9	4.3	4.0	3.2	-0.19	*	3.7	3.3	3.6	3.5
Steak	3.5	-0.2	3.0	2.6	3.2	4.3	4.4	3.2	-0.16		3.1	3.1	3.0	3.7
Gold Plus MF	3.6	-0.1	3.7	3.2	3.7	4.4	4.3	3.2	-0.16		3.5	3.1	3.6	3.6
Genoa	3.5	-0.3	3.5	3.0	3.8	4.6	3.2	3.2	-0.15		3.4	3.3	4.0	3.1
54V54	3.6	-0.1	3.2	2.8	3.5	4.4	4.2	3.3	-0.13		3.2	2.9	3.3	3.6
Pickseed 8925MF	3.5	-0.3	3.6	2.7	3.5	5.2	3.4	3.3	-0.07		3.5	2.8	3.6	3.4
Affinity+Z	3.8	0.1	2.9	3.1	3.7	5.1	4.3	3.3	-0.07		3.0	3.1	3.6	3.6
AC Brador	3.8	0.0	3.3	3.1	3.7	5.1	3.6	3.3	-0.07		3.3	3.1	3.5	3.4
54H91	3.8	0.1	3.4	3.0	3.4	5.1	4.3	3.3	-0.07		3.2	3.2	3.3	3.7
Apex	3.5	-0.3	2.9	2.9	3.7	4.5	4.0	3.3	-0.04		3.2	3.1	3.5	3.6
Surpass	3.7	0.0	3.4	3.0	3.8	4.2	3.9	3.4	-0.03		3.4	3.0	3.5	3.6
Exp586	3.6	-0.1	3.0	2.9	3.3	4.8	3.7	3.4	-0.03		3.1	3.1	3.2	3.7
Radar	3.6	-0.1	3.6	3.2	4.1	4.3	3.6	3.4	-0.02		3.6	3.3	3.8	3.3
WL 319HQ	3.8	0.0	3.3	2.7	3.5	5.0	4.2	3.4	0.00		3.2	2.9	3.4	4.0
OAC Superior	3.8	0.1	3.4	2.9	3.3	5.0	4.0	3.4	0.00		3.5	3.1	3.5	3.6
134	3.6	-0.2	3.4	2.7	3.9	4.4	3.6	3.4	0.02		3.4	2.9	3.7	3.5
Oneida VR	3.8	0.0	3.3	2.7	3.6	4.1	4.1	3.4	0.02		3.0	2.8	3.4	3.7
Exp610	3.8	0.1	3.6	3.4	3.8	5.0	3.9	3.4	0.03		3.5	3.1	3.7	3.4
Ascend	3.8	0.1	3.6	3.0	3.6	4.9	3.9	3.4	0.03		3.3	3.1	3.5	3.7
Magnum IV	3.7	0.0	2.8	2.8	3.6	4.9	4.0	3.4	0.05		2.9	2.9	3.6	3.6
Grazemaster	3.6	-0.1	3.5	2.6	3.6	4.4	3.7	3.4	0.05		3.5	2.9	3.4	3.5
GH700	3.7	0.0	3.5	3.1	3.9	4.9	3.9	3.4	0.05		3.2	3.2	3.6	3.5
Valiant	3.8	0.1	3.4	2.6	3.8	5.0	4.2	3.4	0.05		3.4	2.9	3.7	3.8
Magnum III-Wet	3.7	0.0	3.3	3.1	4.0	4.3	4.0	3.4	0.06		3.4	3.1	3.6	3.7
Exp624	4.0	0.2	3.5	2.4	3.9	4.9	4.0	3.5	0.07		3.4	2.9	3.6	3.5
WL 327	3.8	0.1	3.5	2.6	3.7	4.5	4.6	3.5	0.08		3.4	2.9	3.5	4.0
Hybri-Force 400	3.8	0.1	3.4	2.6	3.6	4.1	4.2	3.5	0.08		3.3	2.8	3.2	3.7
Stealth SF	3.8	0.1	3.4	3.0	3.7	5.1	4.1	3.5	0.09		3.4	3.0	3.6	3.9
Rhino	3.9	0.2	3.4	2.6	3.2	4.2	3.7	3.5	0.10		3.3	2.9	3.2	3.6
Multiplier 3	3.8	0.0	3.2	3.3	3.6	4.4	4.0	3.5	0.11		3.3	3.2	3.6	4.0
54V46	3.8	0.1	3.4	3.1	3.6	4.6	4.3	3.5	0.12		3.5	3.1	3.3	4.0
FSG 300LH	4.0	0.3	3.5	2.9	3.9	5.0	4.6	3.5	0.12		3.4	3.2	3.9	4.1
WinterGold	3.9	0.2	3.3	3.0	3.9	5.0	4.4	3.5	0.12		3.3	3.3	3.6	3.8
Geneva	4.0	0.2	3.3	2.9	4.0	4.4	4.8	3.5	0.15		3.4	3.0	3.8	4.0
Exp635	3.9	0.1	3.1	2.6	3.3	4.2	4.0	3.5	0.16		3.2	3.1	3.5	3.7
Pickseed 2065MF	3.8	0.1	3.1	2.9	4.0	4.8	3.6	3.6	0.17		3.2	3.1	3.7	3.6
Forecast 1001	3.7	0.0	3.6	3.1	4.0	5.1	3.6	3.6	0.21	*	3.6	2.9	3.8	3.7
Satellite	3.9	0.2	3.8	3.0	4.4	4.5	3.7	3.6	0.23	*	3.5	3.0	4.3	3.6
Starbuck	4.0	0.2	3.3	3.0	4.4	5.0	4.1	3.6	0.24	*	3.3	3.1	4.1	4.0
Stallion	4.0	0.3	3.6	3.2	4.2	4.7	4.4	3.7	0.30	*	3.6	3.2	4.0	4.0
Enhancer	3.9	0.2	3.8	2.6	3.7	5.0	4.2	3.7	0.31	*	3.7	2.9	3.6	4.0
mean	3.7		3.4	2.9	3.7	4.6	4.0	3.4			3.6	3.6	3.6	3.6
se	0.12		0.28	0.28	0.28	0.28	0.28	0.09			0.19	0.19	0.19	0.19
LSD (0.05)	0.34		0.77	0.77	0.77	0.77	0.77	0.26			0.52	0.52	0.52	0.52

* = significantly different from the test mean according to a t-test (P=0.05).

Table 5. Stem diameter (mm) of Stage 4 maturity stems of 49 alfalfa varieties seeded in 2005 at Elora and Enniskillen and harvested three times in 2006, 2007, and 2008. Design was a simple lattice repeated with two replications and two repetitions. Table sorted based on mean diameter over tests.

	Harvest 1, Diameter (mm)						Mean over harvests 2006, 2007, 2008	
		2006		2007		2008		
	Mean	Elora	Enniskillen	Elora	Enniskillen	Enniskillen	combined	
Affinity+Z	2.7	2.6	2.6	3.3	2.9	2.3	2.43	*
54V54	2.9	3.1	3.1	3.1	3.0	2.1	2.48	*
Pickseed 2065MF	3.0	3.0	3.3	3.3	3.0	2.3	2.48	*
Reliance	3.1	3.1	3.2	3.3	2.9	2.9	2.51	*
Amerigraze 401+Z	3.0	3.1	3.1	3.4	2.9	2.5	2.51	*
53V52	3.1	2.9	2.6	3.6	3.4	3.0	2.52	
Exp610	3.2	3.6	3.2	3.3	3.1	2.7	2.53	
Exp624	3.1	3.1	3.2	3.1	3.1	2.7	2.53	
Grazemaster	3.1	2.8	4.5	3.0	2.6	2.6	2.54	
WL 319HQ	3.1	2.9	3.4	3.5	2.9	2.8	2.55	
Jolt	3.1	3.2	2.7	3.9	2.9	2.9	2.57	
Valiant	3.1	3.4	3.8	3.4	2.7	2.4	2.58	
WL 327	3.1	3.2	3.1	3.2	3.1	3.3	2.59	
Enhancer	2.7	3.1	3.1	3.1	2.7	1.6	2.59	
54V46	3.0	3.2	3.1	3.1	3.3	2.4	2.59	
Forecast 1001	3.1	3.1	3.1	3.4	2.8	3.2	2.59	
Steak	3.3	3.5	3.0	3.3	3.4	3.0	2.61	
Oneida VR	3.3	3.3	4.0	3.2	2.9	3.1	2.61	
Stealth SF	3.2	3.2	3.4	3.4	2.8	3.2	2.62	
Exp586	3.3	2.9	3.4	3.6	3.4	3.2	2.62	
AC Brador	3.2	3.2	3.3	3.0	2.9	3.4	2.63	
Approved	3.1	3.1	3.6	3.2	3.0	2.5	2.63	
Multiplier 3	3.3	3.4	3.0	3.3	3.3	3.5	2.63	
Gold Plus MF	3.1	3.4	3.3	3.7	2.9	2.1	2.63	
Ascend	3.2	3.4	3.2	3.5	2.8	3.1	2.64	
Radar	3.4	3.2	3.6	3.5	3.2	3.5	2.66	
Magnum III-Wet	3.2	3.4	3.0	3.3	3.2	3.4	2.66	
Geneva	3.1	3.2	3.0	3.4	3.1	2.8	2.67	
Hybri-Force 400	3.3	3.5	3.6	3.3	3.5	2.4	2.67	
Rhino	3.0	3.1	2.8	3.3	3.1	3.0	2.68	
OAC Superior	3.2	3.2	3.2	3.5	3.3	3.1	2.69	
Dominion	3.2	3.3	3.3	3.0	3.3	3.1	2.69	
Surpass	3.2	3.4	3.4	3.3	3.0	2.8	2.69	
Marquis	3.5	3.4	3.9	3.4	3.1	3.8	2.69	
Guardsman II	3.3	4.1	3.1	3.2	2.9	3.1	2.70	
Apex	3.3	3.5	3.4	3.4	2.8	3.6	2.71	
FSG 300LH	3.2	3.5	3.4	3.6	2.9	2.8	2.72	
GH700	3.4	3.3	3.5	3.6	3.1	3.6	2.73	
54H91	3.3	3.4	3.3	3.3	3.0	3.3	2.73	
Pickseed 8925MF	3.0	3.2	3.6	3.6	3.0	1.9	2.73	
Satellite	3.3	3.5	3.9	3.4	3.0	2.5	2.73	
Genoa	3.3	3.3	3.5	3.2	3.2	3.2	2.74	
Macon	3.4	3.7	3.4	3.2	2.9	3.6	2.75	
Stallion	3.3	3.4	3.6	3.6	3.1	3.0	2.77	
Starbuck	3.4	3.6	3.4	3.0	3.5	3.5	2.77	
Exp635	3.4	3.5	3.6	3.7	3.3	3.1	2.78	
WinterGold	3.5	4.0	3.9	3.4	3.1	3.0	2.81	*
134	3.5	3.9	3.5	3.8	3.1	3.2	2.84	*
Magnum IV	3.2	3.2	3.5	3.3	3.1	3.1	2.89	*
mean	3.2	3.3	3.4	3.3	3.0	2.9	2.65	
se	0.14	0.31	0.31	0.31	0.31	0.31	0.073	
LSD (0.05)	0.38	0.85	0.85	0.85	0.85	0.85	0.202	

* = significantly different from the test mean according to a t-test (P=0.05).

Manure, Traffic, and Aeration Effects

The treatments were first applied following the first and second harvests in 2006, 2007, and 2008. Yields were recorded for each of the three harvests in each year. Since the treatments were first applied following first harvest in 2006, total yield produced from the plots since that time were analyzed to determine differences among treatments.

Traffic Stress

In the first year of the study, there was negligible effects detected for the traffic stress. As the trial continued into the second and third production years, differences among treatments became more evident. This was consistent with other studies in that the impact of stresses on alfalfa became more pronounced as the stand ages. In 2007, the traffic stress decreased herbage yield by 5% averaged across varieties, and in 2008, the decrease was over 9% (Table 6). Over the three years, the average reduction in yield due to traffic stress was 5.2% averaged over all varieties.

Manure Application

The increase in herbage yield due to two applications of 4500 gal/acre liquid manure each year ranged from 6 to 32% (Table 6). The average increase over the three year period was 14.5%. The greatest yield increase was detected in 2007. This was a particularly dry season but in a related study which involved a water treatment (Bowman, 2009), this manure response was due to the nutrients not the water per se. In 2008, the average response to the manure application (a 6% increase) was similar to that observed in 2006. There were also interactions with variety as some varieties showed greater response and others showed lower than average response to the application; increases ranged from 2.4 to 27.4% among the varieties over the three year period (Table 7).

Aeration & Manure

Aeration, in combination with the manure application, was detrimental to yields, although there were still yield increased of 10.1% over the control. In this test, the aeration treatment *per se* decreased yield by 2-3% (compare Manure with Manure+Aeration). Studies by Bowman (2009) have revealed that an aeration treatment per se increased herbage yield of alfalfa stands. This may relate to changes in aeration in the upper root zone. However when combined with manure application, the effect of aeration was reduced, and at high manure (6000 gal/acre) applications, negated. It is possible that the aeration treatment increased the direct root-manure contact which may be detrimental to the alfalfa stand.

There were differences among varieties in their response to traffic, manure, and manure application in conjunction with aeration (Table 7). The last three columns present the variety's yield as a percent of its yield under the control treatment. Some varieties were very sensitive to traffic (eg. 53V52) while others were relatively unaffected by traffic (eg. AC Brador). Similarly, some varieties were highly responsive to manure application (eg. Reliance) while others were not as responsive to the manure application (eg. Jolt). There were also differences in their reaction to the aeration treatment. Since there was not an aeration treatment alone, the effect was measured by comparing the yield of the aeration+manure treatment to the manure treatment yield (see last column in Table 7). Again, some varieties were unaffected by the aeration treatment in conjunction with the manure application (eg. Genoa) while others had sizable declines in yield when aeration was used (eg. Gold Plus MF).

Table 6. Herbage yield (T DM/ha) of 49 alfalfa varieties seeded in 2005 at Elora and harvested three times in 2006, 2007, and 2008.

Following the first and second harvest in each year, plots were subjected to one of the four following management stresses: control, wheel traffic, manure, and manure + aeration. Design was a split plot with two replications; varieties within a replication were arranged in a lattice design. Three year total is total yield following initial application of treatments.

	Total herbage yield (T/ha)				Total yield as % of control treatment			
Treatment	2006	2007	2008	3 year total	2006	2007	2008	3 year total
Control	7.1	9.0	11.5	27.6	100.0 a	100.0 b	100.0 ab	100.0 b
Traffic	7.2	8.5	10.4	26.1	100.8 a	95.1 b	90.8 b	94.8 c
Manure	7.5	11.8	12.2	31.5	106.1 a	131.8 a	106.3 a	114.5 a
Manure + Aeration	7.4	11.3	11.7	30.4	104.4 a	126.2 a	102.2 ab	110.5 a
se	0.15	0.16	0.33	0.35				

Means within a column followed by the same letter are not significantly different according to a Tukey test (P=0.05).

Table 7. Herbage yield (T DM/ha) of 49 alfalfa varieties seeded in 2005 at Elora and harvested three times in 2006, 2007, and 2008.

Following the first and second harvest in each year, plots were subjected to one of the four following management stresses: control, wheel traffic, manure, and manure + aeration. Design was a split plot with two replications; varieties within a replication were arranged in a lattice design. Three year total is total yield following initial application of treatments..

Varieties with yields higher than average under all four management treatments are indicated in yellow, those that had less yield than average under all four managment treatments are indicated in orange

	2006 to 2008 Total yield (T DM/ha)				3 year total - as % of treatment mean				3-year total -as a % of Control		3-year total -as a % of Manure
Variety	Control	Traffic	Manure	Manure+ Aeration	Control	Traffic	Manure	Manure+ Aeration	Traffic	Manure	Manure+ Aeration
134	27.7	25.6	33.4	32.1	100.6	98.0	106.0	105.5	92.4	120.6	96.0
53V52	30.3	25.4	31.8	30.1	109.8	97.3	100.9	99.0	84.0	105.2	94.7
54H91	26.0	23.3	29.1	27.5	94.2	89.1	92.4	90.5	89.7	112.3	94.5
54V46	29.9	25.1	32.6	31.5	108.4	96.2	103.4	103.4	84.2	109.2	96.5
54V54	27.1	24.4	31.4	29.4	98.4	93.3	99.4	96.6	89.9	115.6	93.8
AC Brador	25.6	26.1	29.1	27.6	93.0	100.0	92.2	90.5	101.9	113.5	94.7
Affinity+Z	25.5	25.7	31.7	29.5	92.5	98.4	100.4	96.8	101.0	124.4	93.1
Amerigraze 401+Z	25.5	24.3	31.3	29.7	92.7	93.0	99.1	97.5	95.2	122.4	95.0
Apex	27.1	26.6	31.7	29.9	98.2	101.9	100.5	98.3	98.4	117.1	94.4
Approved	25.1	26.3	30.0	29.3	91.2	100.6	95.2	96.1	104.6	119.5	97.4
Ascend	28.8	27.4	33.9	32.1	104.6	104.7	107.4	105.4	95.0	117.6	94.7
Dominion	25.4	25.5	29.1	28.3	92.0	97.4	92.1	93.0	100.4	114.6	97.4
Enhancer	27.7	27.4	32.7	31.5	100.4	104.9	103.8	103.6	99.1	118.3	96.4
Exp586	27.4	24.7	29.5	30.2	99.4	94.5	93.4	99.1	90.2	107.6	102.4
Exp610	29.0	28.0	32.3	33.3	105.2	107.1	102.3	109.4	96.5	111.3	103.1
Exp624	28.1	27.9	33.9	33.9	102.1	106.8	107.5	111.3	99.2	120.5	99.9
Exp635	28.7	26.3	29.8	30.4	104.2	100.6	94.5	100.0	91.6	103.9	102.1
Forecast 1001	27.8	26.5	31.4	29.4	100.7	101.3	99.6	96.6	95.4	113.3	93.6
FSG 300LH	26.7	24.3	28.5	29.1	96.9	93.0	90.3	95.5	91.0	106.7	102.1
Geneva	27.1	24.9	33.6	30.7	98.3	95.2	106.5	100.9	91.8	124.0	91.5
Genoa	27.7	27.9	33.6	34.5	100.4	106.8	106.6	113.3	100.9	121.6	102.5
GH700	28.3	25.9	32.6	31.6	102.5	99.2	103.3	103.6	91.8	115.4	96.8
Gold Plus MF	27.6	27.0	32.3	29.3	100.1	103.4	102.3	96.3	98.0	117.1	90.9
Grazemaster	28.5	28.4	32.8	31.5	103.5	108.6	104.1	103.6	99.5	115.2	96.0
Guardsman II	27.0	27.4	31.0	30.7	98.1	105.0	98.3	100.7	101.5	114.7	98.9
Hybri-Force 400	26.3	28.6	32.3	30.9	95.6	109.6	102.3	101.4	108.7	122.5	95.7
Jolt	29.0	26.6	29.7	28.8	105.3	101.7	94.1	94.6	91.6	102.4	97.0
Macon	25.9	26.6	29.8	26.5	94.2	101.8	94.5	87.0	102.5	114.9	88.9
Magnum III-Wet	27.2	24.4	31.7	31.1	98.7	93.5	100.3	102.0	89.8	116.3	98.1
Magnum IV	26.7	27.5	31.5	30.5	96.9	105.1	99.9	100.1	102.8	117.9	96.7
Marquis	25.8	25.8	29.9	28.7	93.6	98.5	94.7	94.3	99.9	115.9	96.1
Multiplier 3	25.1	23.2	28.2	27.0	91.2	88.6	89.5	88.8	92.1	112.3	95.7
OAC Superior	28.6	25.5	33.3	29.7	103.9	97.5	105.4	97.5	89.0	116.2	89.2
Exp9041	28.8	25.1	31.5	28.6	104.4	95.9	99.7	94.1	87.1	109.3	91.0
Pickseed 2065MF	28.9	25.7	32.6	30.9	104.9	98.5	103.3	101.6	89.0	112.7	95.0
Pickseed 8925MF	24.6	24.1	29.1	29.1	89.3	92.1	92.2	95.6	97.8	118.2	100.1
Radar	30.3	26.9	31.4	31.9	109.9	102.9	99.4	104.9	88.8	103.6	101.8
Reliance	25.8	23.1	32.9	31.1	93.7	88.2	104.3	102.0	89.3	127.4	94.4
Rhino	27.8	25.3	30.8	28.8	100.7	96.8	97.6	94.6	91.2	111.0	93.5
Satellite	27.1	26.2	32.7	31.4	98.5	100.2	103.6	103.2	96.5	120.4	96.2
Stallion	27.8	28.0	30.1	29.6	100.9	107.1	95.4	97.2	100.6	108.2	98.3
Starbuck	26.3	24.9	32.7	30.6	95.3	95.3	103.6	100.4	94.8	124.4	93.5
Steak	28.3	25.9	29.0	28.1	102.8	99.1	92.0	92.4	91.4	102.4	97.0
Stealth SF	31.3	30.2	35.9	34.3	113.6	115.4	113.9	112.5	96.3	114.8	95.3
Surpass	28.4	25.6	32.8	32.7	102.9	98.0	104.0	107.4	90.3	115.7	99.7
Valiant	29.2	29.2	32.9	32.8	106.1	111.7	104.2	107.6	99.9	112.4	99.7
Wintergold	29.2	25.9	32.2	32.3	106.1	99.2	102.1	106.0	88.6	110.2	100.2
WL 319HQ	28.9	30.1	32.6	32.5	104.9	115.2	103.3	106.9	104.2	112.8	99.9
WL 327	27.3	24.0	31.2	30.8	99.1	91.8	98.7	101.3	87.9	114.1	99.0
Mean	27.6	26.1	31.5	30.4	27.6	26.1	31.5	30.4			
Mean as % of control	100.0	94.8	114.5	110.5							
se -trt x entry	1.27										
se -trt means	0.35										

Seeding Rate Effects

Yield

As seeding rate increased, there was a negligible effect on herbage yield (Table 8). Yields declined on average 0.013 T/ha for every 1 kg increase in seeding rate. This is a 0.14 % decline in yield for every kg increase in seeding rate.

MSW

As seeding rate increased, the forage was more immature when all plots were harvested on the same date (Table 9). The pattern of decrease in MSW as seeding rate increased was linear. Across all varieties, for every kg increase in seeding rate, the MSW declined by a value of 0.034 units. There were no significant interactions between locations and seeding rate, and between locations and variety. All varieties significantly declined in MSW as seeding rate increased. Variety 54V46 had the greatest change in MSW and OAC Superior the least change in MSW as seeding rate was altered (Table 9).

Stage 4 stem diameter

As seeding rate increased, the stem diameter of Stage 4 stems at the first harvest declined (Table 10). The pattern of decrease in diameter as seeding rate increased was linear. Across all varieties, for every kg increase in seeding rate, the diameter declined by a value of 0.012 mm. There were no significant interactions between locations and seeding rate, and between locations and variety. Magnum IV showed the greatest decline in stem diameter as seeding rate was altered. In contrast, 54V54 was unaffected by seeding rate.

Stem density

The stem density (number of stems per unit area) was recorded at the Enniskillen site in 2008. Data have been expressed as number per square foot (Table 10). As seeding rate increased, the number of stems per unit area increased, on the order of 0.7 to 1.0 stems ft^2 for every 1 kg/ha increase in seeding rate.

Table 8. Herbage yield (T/ha) of five alfalfa varieties seeded at four rates in 2006 at Elora and Enniskillen and harvested three times in 2007 and 2008.
Design was a randomized complete block with four replications. Average over two years, & two locations.

	Harvest 1, yield (T/ha)						Season total yield (T/ha)					
	Seeding rate (kg/ha)						Seeding rate (kg/ha)					
Variety	5.5	11	16.6	22	Mean	b	5.5	11	16.6	22	Mean	b
54V46	6.4	6.1	5.9	6.1	6.1	-0.020	9.6	9.7	9.6	9.7	9.6	0.001
54V54	6.3	6.3	6.0	5.7	6.1	-0.037	9.9	9.8	9.7	8.9	9.6	-0.057
Ascend	5.9	6.1	6.2	6.1	6.1	0.015	9.7	9.7	9.8	10.0	9.8	0.020
Magnum I\	6.4	6.0	6.0	5.8	6.0	-0.031	10.1	9.5	9.4	9.2	9.6	-0.051
OAC Super	5.9	6.6	6.2	6.2	6.2	0.009	9.2	10.3	9.6	9.8	9.7	0.020
Mean	6.2	6.2	6.1	6.0		-0.013	9.7	9.8	9.6	9.5		-0.013
	Variety x rate	Rate means	Variety means				Variety x rate	Rate means	Variety means			
se	0.28	0.21	0.21			0.0080						0.0096
LSD (0.05)												

Table 9. Mean stage by weight (MSW) of five alfalfa varieties seeded at four rates in 2006 at Elora and Enniskillen and harvested three times in 2007 and 2008.
Design was a randomized complete block with four replications. Average over two years, & two locations.

	Harvest 1, MSW						Season weighted MSW					
	Seeding rate (kg/ha)						Seeding rate (kg/ha)					
Variety	5.5	11	16.6	22	Mean	b	5.5	11	16.6	22	Mean	b
54V46	4.4	3.7	3.7	3.4	3.8	-0.052	4.0	3.5	3.4	3.1	3.5	-0.052
54V54	3.5	3.6	3.3	3.1	3.4	-0.033	3.3	3.3	3.0	2.9	3.1	-0.027
Ascend	4.1	3.7	3.5	3.7	3.8	-0.032	4.0	3.6	3.3	3.4	3.5	-0.037
Magnum IV	3.9	3.6	3.3	3.4	3.6	-0.034	3.7	3.3	3.1	3.1	3.3	-0.034
OAC Superior	3.8	3.6	3.7	3.5	3.6	-0.015	3.5	3.4	3.3	3.2	3.3	-0.020
Mean	4.0	3.7	3.5	3.4		-0.033	3.7	3.4	3.2	3.1		-0.034
	Variety x rate	Rate means	Variety means				Variety x rate	Rate means	Variety means			
se	0.16	0.11	0.10			0.0067	0.14	0.11	0.09			0.0070
LSD (0.05)												

Table 10. Diameter of maturity stage 4 stems of five alfalfa varieties seeded at four rates in 2006 at Elora and Enniskillen and harvested three times in 2007 and 2008.
Design was a randomized complete block with four replications. Average over two years, & two locations.

	Harvest 1, diameter (mm)						Season average diameter (mm)					
	Seeding rate (kg/ha)						Seeding rate (kg/ha)					
Variety	5.5	11	16.6	22	Mean	b	5.5	11	16.6	22	Mean	b
54V46	2.9	3.1	3.2	2.6	3.0	-0.016	2.6	2.5	2.7	2.3	2.5	-0.014
54V54	3.1	3.0	2.9	3.2	3.0	0.003	2.6	2.8	2.7	2.7	2.7	0.003
Ascend	3.2	3.0	2.8	3.0	3.0	-0.009	2.8	2.7	2.4	2.6	2.6	-0.013
Magnum I\	3.2	3.1	2.8	2.6	2.9	-0.035	2.8	2.7	2.6	2.4	2.6	-0.024
OAC Super	3.2	3.2	2.9	3.1	3.1	-0.016	2.8	2.8	2.4	2.7	2.7	-0.012
Mean	3.1	3.1	2.9	2.9		-0.015	2.7	2.7	2.5	2.6		-0.012
	Variety x rate	Rate means	Variety means				Variety x rate	Rate means	Variety means			
se	0.17	0.13	0.13			0.0051	0.13	0.10	0.10			0.0039

Table 11. Stem density (number /ft2) of five alfalfa varieties seeded at four rates in 2006 at Enniskillen and harvested three times in 2007 and 2008. Design was a randomized complete block with four replications. Average over two years, & two locations.

	Harvest 1, Stem density (#/ft2)					
	Seeding rate (kg/ha)					
Variety	5.5	11	16.6	22	Mean	b
54V46	53	46	63	75	59	1.5
54V54	39	63	63	61	56	1.2
Ascend	59	54	45	57	53	-0.3
Magnum IV	54	60	59	75	62	1.1
OAC Superior	64	45	57	62	57	0.1
Mean	54	53	57	66		0.7
	Variety x rate	Rate means	Variety means			
se	7.2	3.2	3.6			0.28

	Harvest 2, Stem Density (#/ft2)					
	Seeding rate (kg/ha)					
Variety	5.5	11	16.6	22	Mean	b
54V46	70	75	69	67	70	-0.3
54V54	68	60	85	86	74	1.4
Ascend	47	58	72	72	62	1.6
Magnum IV	74	105	69	105	88	1.0
OAC Superior	66	65	78	88	74	1.5
Mean	65	72	74	83		1.0
	Variety x rate	Rate means	Variety means			
se	11.3	5.1	5.7			0.44

	Harvest 3, Stem Density (#/ft2)					
	Seeding rate (kg/ha)					
Variety	5.5	11	16.6	22	Mean	b
54V46	52	55	60	53	55	0.2
54V54	60	55	65	51	57	-0.3
Ascend	42	56	58	60	54	1.0
Magnum IV	55	48	80	72	63	1.5
OAC Superior	48	72	70	77	67	1.5
Mean	51	57	66	62		0.8
	Variety x rate	Rate means	Variety means			
se	4.2	1.9	2.1			0.25

DISCUSSION

Maturity and Stem Diameter

There were variety differences for herbage yield, for maturity, as well as stem diameter (Stage 4 stems). These attributes are, in general, not related. Herbage yield was not correlated with season weighted MSW (r=0.17 P=0.2383) and not correlated with Stage 4 diameter (r=0.05 P=0.7538). Furthermore, maturity was not correlated to Stage 4 stem diameter (r=0.26 P=0.0650).

The absence of strong correlation revels that if either maturity or stem diameter is an issue for producers, then both management (harvest timing) and variety selection are factors that should be considered in designing a system to produce the desired harvested product. For example, harvesting at an earlier stage of development will result in a forage that has a greater proportion of finer stemmed, less mature material. In the present study, the varieties were all harvested on the same date with the finding that varieties differed not only in their maturity but also in their diameter of Stage 4 stems. Thus, one could leave harvest date unchanged but modify the maturity/diameter profile by changing the variety.

The absence of correlation among the three attributes (yield, maturity, and diameter) provides the opportunity to mix and match desirable traits but increases the complexity of selecting a variety that has an optimal combination. Of these three traits, herbage yield is probably the attribute of greatest importance. So, a method of selecting varieties would be to choose from among varieties with greater than average yield and, from among those varieties, select the ones with the desired performance for maturity, diameter, or both.

Figure 1 illustrates a scatterplot of average yield and average maturity of the 49 varieties. These values combine all data from each year. The graph has been bisected with lines marking the average yield and the average maturity of the trial. Varieties on the right side are varieties that had greater than average yield. Those in the upper right quadrant are varieties that were more mature on average, those in the lower right quadrant are varieties that were less mature on average.

A similar bi-plot could also be constructed for yield by diameter and for maturity by diameter, however, it was desired to present all three variables in a single graph. The stem diameter results have been incorporated into Figure 1 by using different symbols to plot the variety means. Varieties that had Stage 4 stems that were smaller in diameter than average are indicated using an asterisk (*), those that were larger in diameter are plotted with a plus (+) sign.

Figure 2 is the same plot as Figure 1 but only presents the varieties that had an average Stage 4 stem diameters that were less than the test mean. Varieties in the lower right quadrant are varieties that had a mean yield higher than the test mean, a maturity index lower than the test mean, and had Stage 4 stems that were smaller in diameter than the test mean.

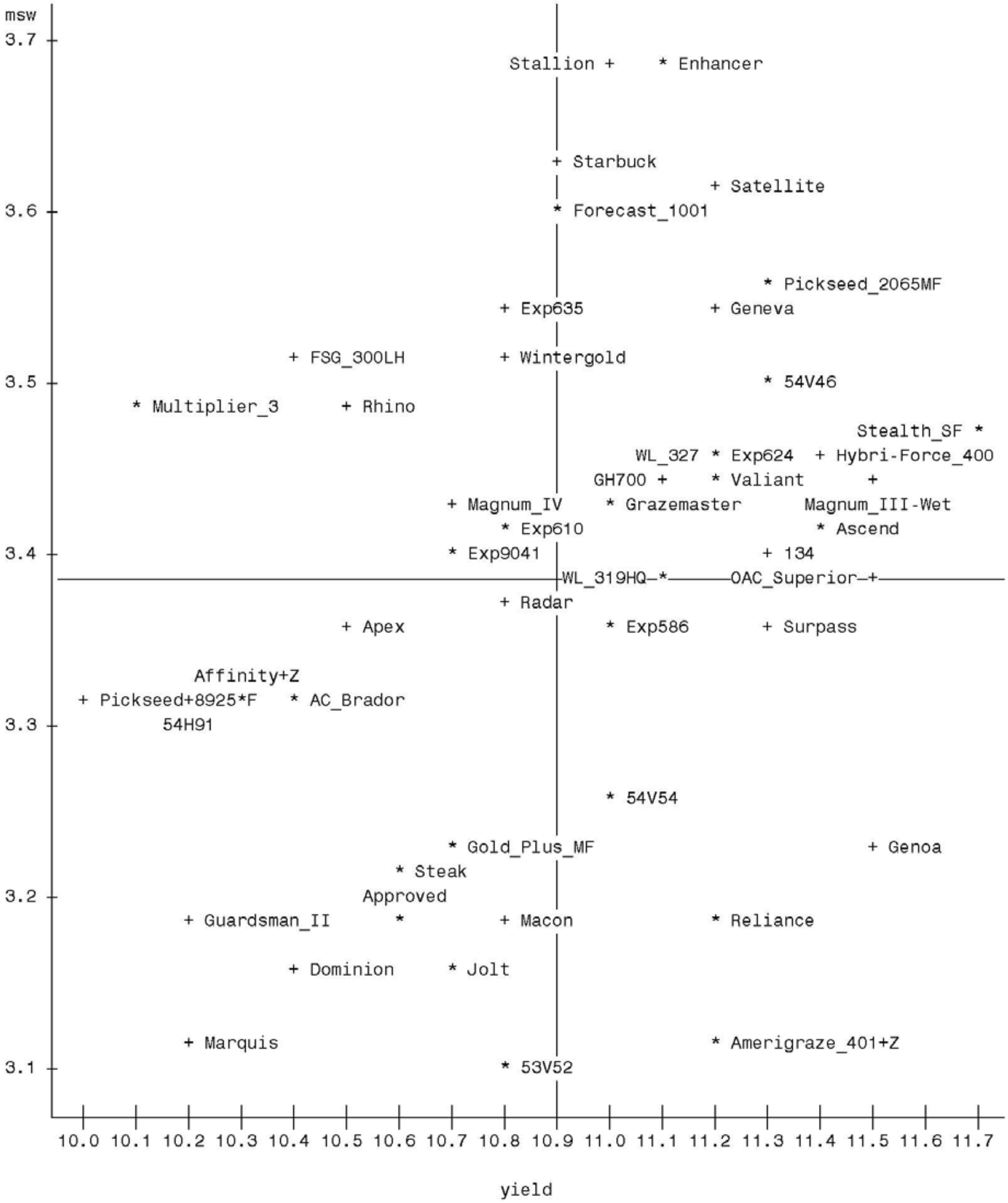

Figure 1. Scatterplot of mean seasonal herbage yield (T DM / ha) and season weighted mean stage by weight (MSW) of 49 varieties of alfalfa seeded in 2005 and evaluated over a three harvest management in 2006, 2007, and 2008, Elora and Enniskillen, Ontario. Design was a simple lattice repeated with two replications and two repetitions. The graph has been bisected with plots showing the test mean for mean yield and mean MSW. Varieties that had Stage 4 stems that were smaller in diameter than the test mean were plotted with the symbol * and those with stems larger in diameter than the test mean were plotted with the symbol +.

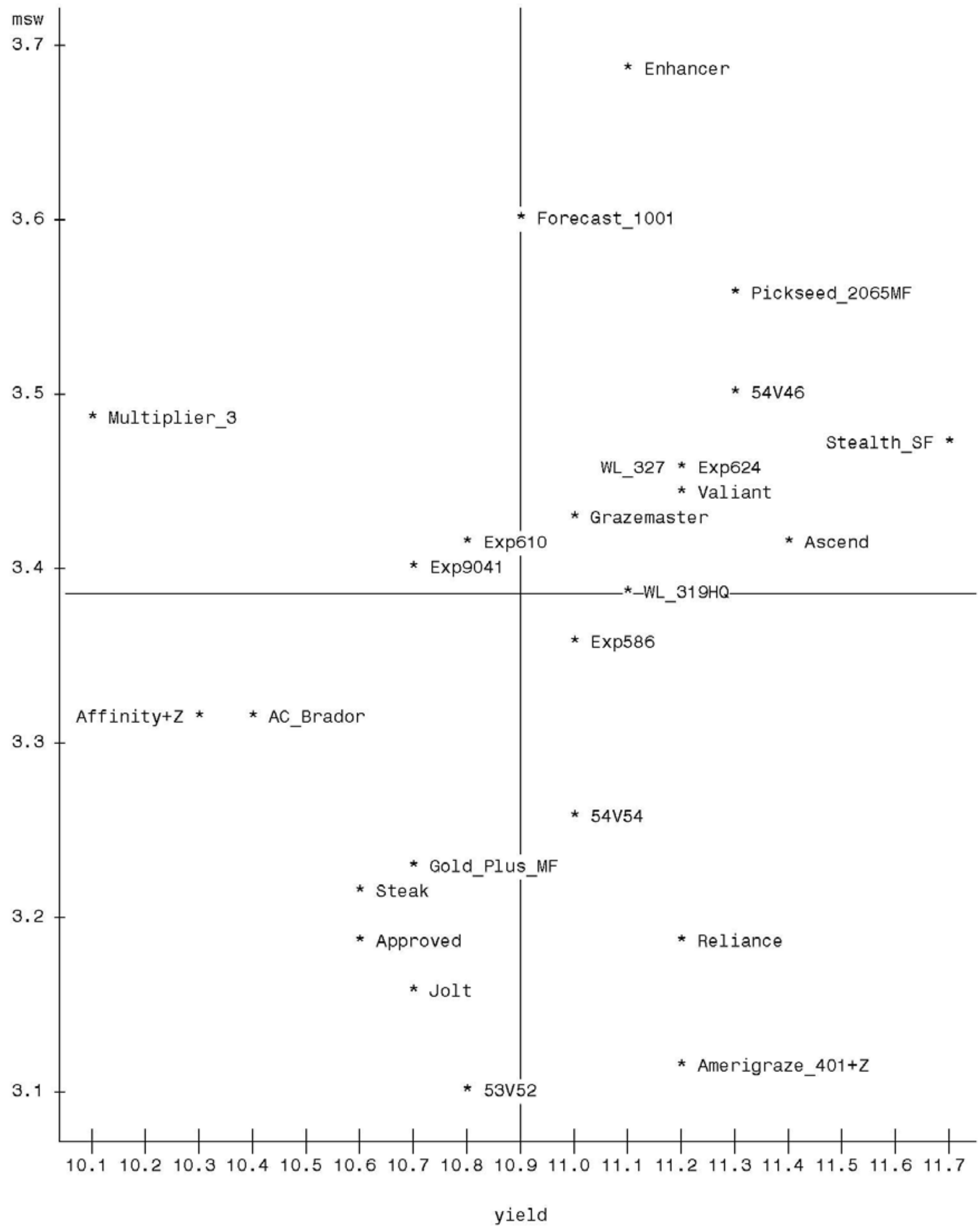

Figure 2. Scatterplot of mean seasonal herbage yield (T DM / ha) and season weighted mean stage by weight (MSW) of 49 varieties of alfalfa seeded in 2005 and evaluated over a three harvest management in 2006, 2007, and 2008, Elora and Enniskillen, Ontario. Design was a simple lattice repeated with two replications and two repetitions. The graph has been bisected with plots showing the test mean for mean yield and mean MSW. Varieties plotted were only those that had Stage 4 stems that were smaller in diameter than the test mean.

Seeding rate

Alfalfa seeded at higher seeding rates will, when harvested on the same date, be less mature than stands seeded at lower seeding rates. This relationship was found for all harvests of the season. Concurrently, there were declines in stem diameter. For the five varieties tested, there were differences in their reaction to changes in seeding rate. At higher seeding rates, the herbage was more immature, but the relative change in maturity differed between varieties.

Traffic and Manure

There were differences among varieties in their response to the application of traffic and manure, either with or without aeration. In general, there was a positive correlation between herbage yield of the control treatment and yield under the various stresses (r ranged from 0.54 to 0.59, P=0.0001). Nonetheless, there were interactions detected in the responses of the varieties.

Bi-plots were constructed to present the differences in variety response following the application of the various management treatments. Figure 3 is a scatterplot of the control yield of the 49 varieties and the yields when 4500 gal/acre liquid manure application was applied after first and second harvest in 2006, 2007 and 2008. The graph has been bisected with lines marking the average yield for each treatment. Those on the right side are varieties that had greater than average control yield. Those in the upper right quadrant are varieties that had greater than average yield under manure application; those in the lower right quadrant are varieties that yielded less than average under manure application.

A similar bi-plot could also be constructed for control yield and yield under traffic stress (or yield under manure plus aeration treatment), however, it was desired to combine all three variables in a single graph. The traffic stress results have been incorporated into Figure 3 by using different symbols to plot the variety means. Varieties that had higher yields than average under traffic stress are indicated using an asterisk (*), those that were lower than average yield under traffic stress are plotted with a plus (+) sign.

Figure 4 is the same plot as Figure 3 but only presents the varieties that had an average yield under traffic stress that was higher than the test mean. Varieties in the upper right quadrant are varieties that had a mean yield higher than the test mean under the control treatment, a yield higher than the mean under the manure treatment, and had a yield higher than the mean of the trial under the traffic stress treatment.

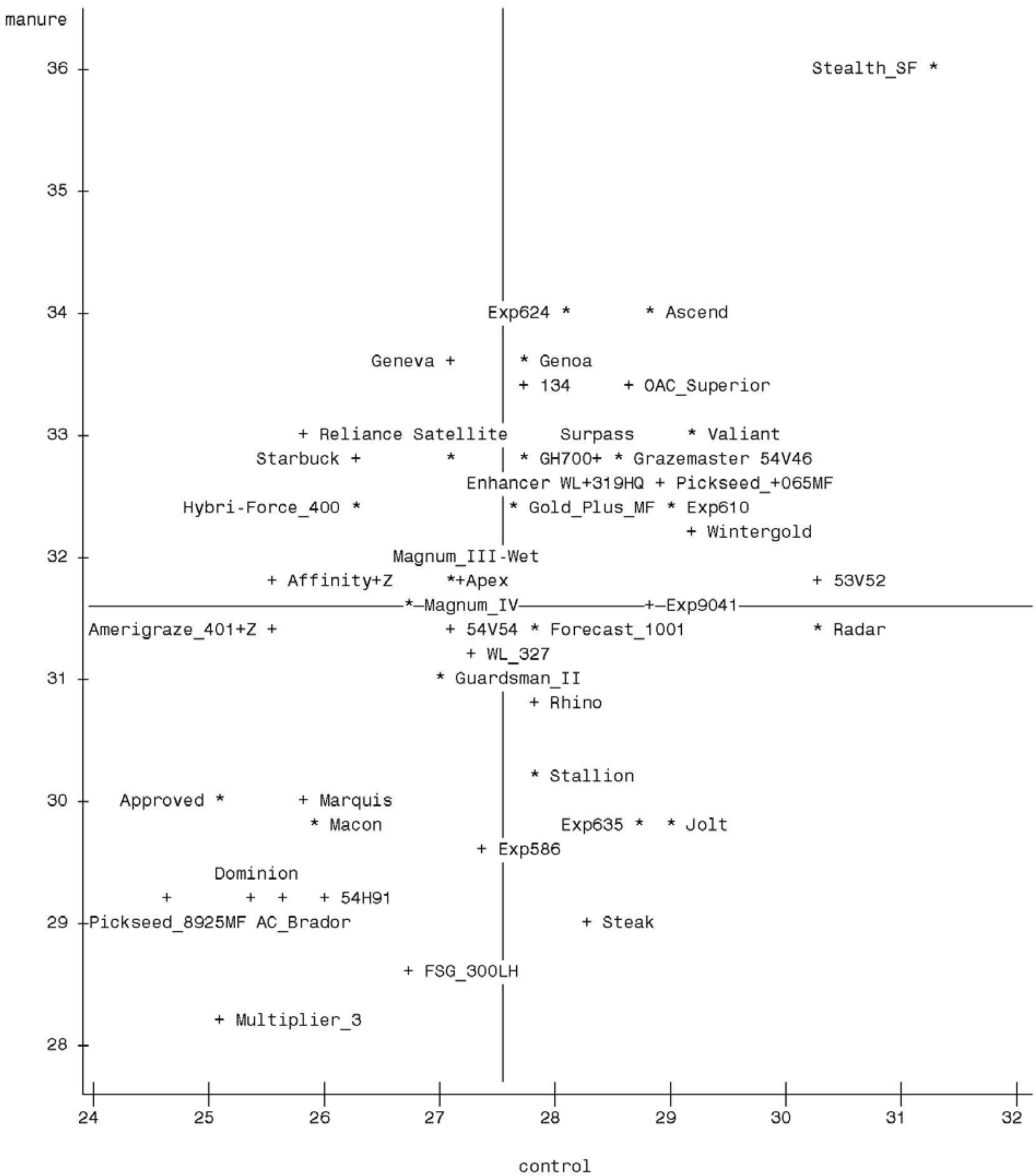

Figure 3. Scatterplot of total herbage yield (T DM / ha) following the initial application of treatments for the control treatment and a liquid manure application (4500 gal/acre) applied after first and second harvest in years 2006, 2007, and 2008 of 49 varieties of alfalfa seeded in 2005 and evaluated over a three harvest management in 2006, 2007, and 2008 at Elora, Ontario. The trial arrangement was a split-plot with two replicates with entries allocated using a balanced lattice randomization. The graph has been bisected with plots indicating the mean for the two treatments. Varieties that had mean yields higher than the mean under the traffic stress treatment were plotted with the symbol * and those with yield lower than the traffic stress treatment mean were plotted with the symbol +.

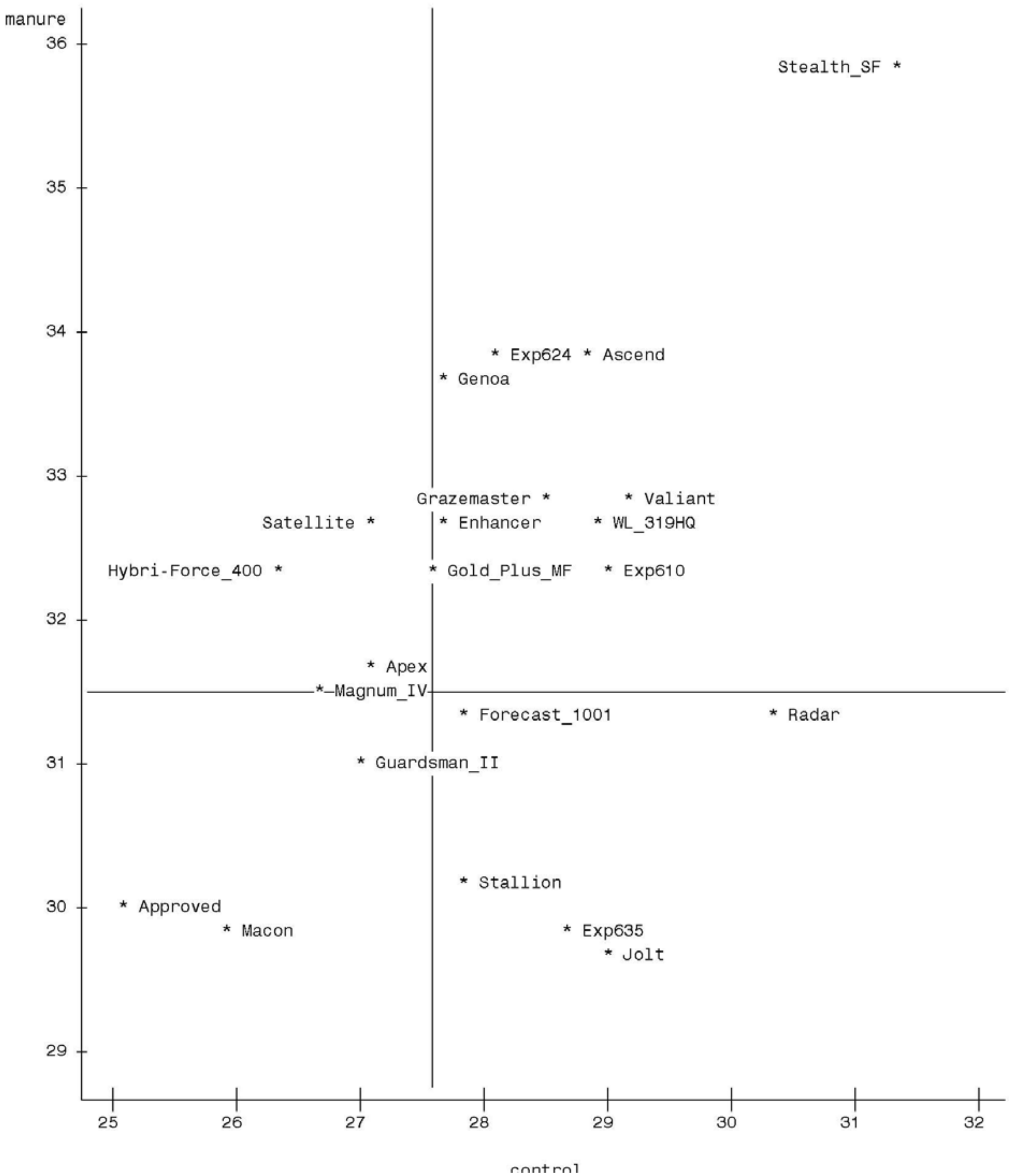

Figure 4. Scatterplot of total herbage yield (T DM / ha) following the initial application of treatments for the control treatment and a liquid manure application (4500 gal/acre) applied after first and second harvest in years 2006, 2007, and 2008 of 49 varieties of alfalfa seeded in 2005 and evaluated over a three harvest management in 2006, 2007, and 2008 at Elora, Ontario. The trial arrangement was a split-plot with two replicates with entries allocated using a balanced lattice randomization. The graph has been bisected with plots indicating the mean for the two treatments. Varieties plotted are only those that had mean yields higher than the mean under the traffic stress treatment.

Discussion

The results of this study have provided additional information regarding alternate management systems for alfalfa. The most notable result is that liquid manure applications after first and second harvests can be included in alfalfa production systems with no apparent detrimental effect on persistence or herbage yield. Indeed, herbage yields were improved in this study. The responses to liquid manure application were a result of the nutrients, not the water per se (Bowman, 2009).

In this particular study, an application of 4500 gal/acre of liquid manure after first and second harvest increased herbage yield on the order of 14.5% over the three years averaged over all varieties (Table 6). There were interactions with variety as some varieties showed greater response and others showed lower than average response to the application; increases ranged from 2.4 to 27.4% among the varieties (Table 7). Aeration, in combination with the manure application, was detrimental to yields, although there were still yield increased of 10.1% over the control. Studies by Bowman (2009) have revealed that an aeration treatment per se increased herbage yield of alfalfa stands. This may relate to changes in aeration in the upper root zone. However when combined with manure application, the effect of aeration was reduced, and at high manure applications, negated. It is possible that the aeration treatment increased the direct root-manure contact which may be detrimental to the alfalfa stand.

Combining the information from the various trials, reveals that incorporation of liquid manure into an alfalfa production system is of benefit for forage yield production. All varieties showed a numerical yield increase under the 4500 gal/acre biannual treatment application. However, the magnitude of the change varied depending on the variety. For producers, this provides for two additional times of the year (late May/early June and Mid-late July) for application/disposal of liquid manure for livestock farms. These application times may also have less nutrient losses compared to late fall or late winter applications. However, the impact of these applications of liquid manure on the nutritional composition of the feed also needs to be assessed.

Reports and Presentations

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Training of **Highly Qualified Personnel** (**HQP**)

Bowman, A. MSc thesis, University of Guelph (in preparation).