Title:
ENVIRONMENTALLY SOUND HIGH IMPACT FORAGE MANAGEMENT RESEARCH BASED DEMONSTRATIONS FOR INCREASED LIVESTOCK PROFITABILITY BY INCREASING FORAGE PRODUCTION AND QUALITY

Investigators:
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Objectives, including relevance of project to Missouri fertilizer/lime use:
Livestock producers and landowners read about forage plant, soil fertility, and animal management techniques that can improve pasture eco-systems, carrying capacity and ultimately farm profitability. However, many are not responsive to adopting these current forage management techniques. Many producers have not had access to research plots that demonstrate the short term and long term plant responses to fertility management changes. This project combines multiple demonstrations of University of Missouri research based forage fertility management practices on a strategically selected farmer field location allowing producers to follow changes in pasture eco-system and profitability per acre through on-site demonstrations and field days.

Procedure:
During the spring of 2007, a 5-acre field was identified and soil tested. Based on soil test results and discussions with Extension Specialists, fertilizer dealers, and farmers, eight different fertilizer combinations were applied to field-scale plots containing primarily tall fescue (Table 1). Plot dimensions are 50 feet X 50 feet. Lime was applied as a sub-plot across all treatments. Fertilizer and lime were applied with commercially available fertilizer equipment. The legume fertilizer treatment was further split with red clover and lespedeza being hand seeded in 25 feet X 50 feet plots. A waste lime treatment was added in 2008.

Weather has impacted this research project. A late freeze in April 2007 may have reduced first cutting forage yields. 2008 was a very wet year, and yields may have been higher than normal expectations due to very favorable moisture supplies throughout the growing season. For the months March through August 2008, 25.55 inches of rainfall were recorded at the research site. This was 8.36 inches more rainfall during 2008 compared to the same months during 2007. 2009 was also an extremely cool and wet year which may have impacted yields and forage quality.

Forage was harvested with a mechanical forage harvester during May, August, and October in 2007 and May, August, and November in 2008 and 2009. Four replications per treatment were harvested. Harvested forage was weighed and subsamples were taken for nutrient analysis. Harvest area was measured and dry matter yield was calculated. Subsamples were weighed, dried, and re-weighed to determine moisture content. Subsamples were then sent to a commercial lab for protein, fiber, and mineral analysis.

Weighted 3-year averages were calculated and analyzed to determine the effect of fertilizer treatment on forage yield and percentages of crude protein (CP), acid detergent fiber (ADF), total digestible nutrients (TDN), calcium (Ca), phosphorus (P), potassium (K) and magnesium (Mg).

Results – Yield, nutrient analysis, economic analysis and education and outreach:
Yield: As expected, fertilizer application based on University of Missouri soil test results for a yield goal of 3 tons of hay per acre produced the most forage during the project (Table 2). The red clover (rcl) treatment was second highest yielding and had higher yield than all other treatments except the 50-30-30 treatment. The 50-30-30 treatment only out yielded the 0-0-0 and 0-0-30 treatments.

Clearly, increasing fertilizer increased forage yield. The question remains, is the value of forage production and quality offset by the increased cost of the fertilizer?

Nutrient Analysis: In addition to yield, the production of nutrients, especially energy and protein, are important to beef cattle producers. Average percent CP was higher for the 100-65-60 and 0-65-60 rcl treatments than for the 0-0-0, 50-30-30 and 50-0-0 treatments (Table 3). Total digestible nutrient values, calculated from ADF analysis, were higher for 100-65-60, 0-0-0 and 0-65-60 lespedeza (lesp) treatments than for the 0-30-0 treatment (Table 4).

Nutrient requirements for selected animals common to Missouri beef cattle production settings are listed in Table 9. Crude protein requirements are met by all fertilizer treatments for all selected animals except growing calves with estimated average daily gain (adg) of 2.0 pounds or higher. Total digestible nutrient requirements are met by forage alone for 1,200 pound dry beef cows, 1,200 pound medium milk producing cows at peak lactation and 600 pound steer calves gaining 1.0 lb adg or less. The full fertility treatment met the TDN requirement for 600 pound steer calves gaining 1.5 lbs adg, meaning additional energy from grain or grain by-product feed sources would not need to be fed in order to achieve that level of performance. All other fertilizer treatments would require at least a small amount of energy supplementation to meet gain goals of 1.5 lbs adg. All fertilizer treatments require additional energy supplementation to achieve 2.0 lbs adg for growing calves. Due to the high quality of forage produced in this study, supplementation levels of grain or grain by-products would not be excessive in order to meet production goals of the selected animals listed in Table 9.

The high forage quality achieved in this study is also due to the timing of the first harvest of the year. The first cutting was taken early enough in the growing season to ensure high quality plus provide adequate time in mid- to late-spring for ample re-growth so a second harvest could be made in August. This also contributed to the high yields achieved in this study.

Following the full MU fertilizer recommendations resulted in more yield and produced more pounds of CP and TDN compared to the other fertilizer treatments used in this study.

While forage levels of Ca, Mg and K were statistically different between fertilizer treatments, there was no apparent forage response in these minerals due to differing levels of P or K fertilization (Tables 5, 6 and 7). Phosphorus was the exception in that higher P fertilization rates resulted in higher forage P levels (Table 8). All treatments exceeded animal requirements listed in Table 9 for Ca, Mg and K. Only the 100-65-60 and 0-65-60 lesp treatments met the highest animal requirement for P. Four treatments, 0-30-0, 0-0-0, 50-0-0 and 0-0-30 did not meet the lowest animal P requirement.

Economic Analysis:

The 3-year average budget is found in Table 13. Hay price is based on $36 per 1,200 pound round bale at 85% dry matter, resulting in a price of $70.59 per ton of dry matter. Fertilizer prices are averaged for the three years of the study. Annual fertilizer prices are listed in Table 10. Operating and ownership costs are averaged from budgets prepared by FAPRI for large round bales of fescue / red clover mixed hay for the years of 2007 - 2009.

In Table 11, the 3-year averages for yield and income and treatment ranking of yield and income are shown. Based on these results and cost estimates, it appears producers should fertilize according to soil test, incorporate a high percentage of red clover, or fertilize using minimal amounts of the most limiting nutrient in order to achieve the most profit from a hay production system. Moderate levels of fertilization increased cost over lower fertilization treatments but did not increase forage yield sufficiently to warrant the increased cost of fertilizer application.

As the study progressed, the 50-30-0 and the 0-30-0 treatments improved in yield and income rank while the 50-30-30 and 0-0-30 treatments declined in yield and income rank (see Table 12). This is most likely due to soil nutrient profiles. Initial soil tests taken in the spring of 2007 showed P at 6 pounds per acre (very low) while K was 148 pounds per acre (Medium to High). We are seeing yield responses to P fertilization, but not K fertilization, due to the increased probability of a fertilization response with decreasing soil test nutrient level. Moderate (50 pounds per acre) applications of nitrogen (N) did not improve yield sufficiently to overcome the additional cost of the fertilizer.

It is important for producers to understand that if yield losses occur due to lack of fertilizer application, additional feed resources must be acquired. This can be accomplished by either renting or leasing more acres for hay harvest, purchasing additional hay, protein, or energy supplements, or reducing livestock numbers to reduce feed needs. The cost of additional hay land may vary from costs used in this analysis and must be accounted for by each producer. This relationship between production capability due to fertilization and land costs may be more important in future years as land costs rise and hay and pasture land availability shrink.

Education and Outreach:

Two educational workshops were held in our establishment year. On August 30, 2007, approximately 80 people from eight surrounding counties attended the first field day at the plots. Producers learned of the reasoning behind the fertility treatments, data that was being collected, how that data was going to be used and heard some preliminary data that had been obtained from earlier harvests.

Our second event was held in mid-November and approximately 30 people attended that event. Additional results were presented along with information about nutrient cycles in forage systems and winter feeding programs for beef cattle.

The third educational workshop was held in mid-June 2008. Twenty-five producers from the Montgomery County area toured the site and heard an update on research results.

Our fourth workshop was held on August 12, 2009. Eighty-four percent of survey respondents agreed or strongly agreed that greater attention to forage quality is needed in order to be profitable. Sixty-seven percent would like to see more information about variable rate fertilizer technology. Eight-six percent said they would consider attending future Extension field days. Ninety-five percent agreed or strongly agreed that it is important that Extension continues local field days and research plot work.

Forty-six percent of those in attendance had attended previous field days at the research site. Of these, 64 percent agreed or strongly agreed that their forage management changed because of attending the field day. Fifty-five percent agreed or strongly agreed that information from the last field day helped them change their pasture fertilization management and cope with high 2008 and 2009 fertilizer prices.

The regional specialists involved in the project continue to field questions and hear comments about the plots and the results being obtained there. Results being obtained from this study are highlighted at regional meetings, winter workshops, and grazing schools.

Producers in central Missouri have readily accepted this multi-disciplinary, local research/education approach. To date, over 200 producers from eight counties have attended four on-site workshops. Extension agronomy specialists present plot data on yield and discuss fertilizer management. Nutrient yield and quality differences between fertility treatments as they apply to beef cattle feeding

programs are discussed by Extension livestock specialists. Extension agriculture business specialists highlight the economics of forage production. Producers see the impact of a particular fertilizer program by comparing plots. They learn to incorporate forage quality information into economical beef cattle feeding programs. Producer survey responses include: “You brought up points I hadn’t thought about,” and “You guys always hit the nail on the head.”

Summary points from this research/demonstration project to date are:

- Aggressive harvest management can lead to high yields and high forage quality.
- Producers must decide how to deal with potential reduced yields if the forage fertility program is reduced.
- Producers may need to change fertilizer strategies and target-apply fertilizer when forage is needed and can be harvested in a timely manner, rather than blanket fertilizer applications over all their acres.
- Producers need to consider and compare the costs of supplemental feeds with the cost of fertilizer application to increase tons of hay and pounds of nutrients produced on the farm.
- Producers have changed their forage management as a result attending a project field day.
- Producers have changed their forage fertilizer practices as a result of this project.
- A vast majority of producers attending our field days feel it is important Extension specialists continue doing local research and demonstration projects.

Table 1. Plot layout and treatment identification.

	N only 50-0-0	Synergy 50-30-0	P only 0-30-0	K only 0-0-30	Dealer 50-30-30	Check 0-0-0	Soil Test 100-65-60	Legume 0-65-60	Legume 0-65-60	Waste Lime
Rep 1 No lime	101	201	301	401	501	601	701	801 rcl	901 lesp	111
Rep 1 Lime	102	202	302	402	502	602	702	802 rcl	902 lesp	112
Rep 2 No lime	103	203	303	403	503	603	703	803 rcl	903 lesp	113
Rep 2 Lime	104	204	304	404	504	604	704	804 rcl	904 lesp	114
Rep3 No lime	105	205	305	405	505	605	705	805 lesp	905 rcl	115
Rep 3 Lime	106	206	306	406	506	606	706	806 lesp	906 rcl	116
Rep 4 No lime	107	207	307	407	507	607	707	807 lesp	907 rcl	117
Rep 4 Lime	108	208	308	408	508	608	708	808 lesp	908 rcl	118

rcl= Red Clover, lesp = Lespedeza

Table 2. Three-Year Weighted Yield Results, lbs dry matter per acre.

Treatment	Yield, lbs DM/acre
100-65-60	12,360[a]
0-65-60 rcl	10,068[b]
50-30-30	9,092[bc]
0-65-60 lesp	8,737[cd]
50-30-0	8,485[cd]
0-30-0	8,431[cd]
50-0-0	8,101[cd]
0-0-0	7,655[d]
0-0-30	7,627[d]

Means in columns with different superscripts are different (P<.05)

Table 3. Three-Year Weighted Average CP %.

Treatment	% CP
100-65-60	12.4[a]
0-65-60 rcl	12.4[a]
0-30-0	12.0[ab]
0-0-30	11.7[abc]
0-65-60 lesp	11.4[abc]
50-30-0	11.3[abc]
0-0-0	11.0[bc]
50-30-30	10.8[c]
50-0-0	10.6[c]

Means in columns with different superscripts are different (P<.05)

Table 4. Three-Year Weighted Average TDN %.

Treatment	% TDN
100-65-60	63.5[a]
0-0-0	62.7[ab]
0-65-60 lesp	62.6[ab]
0-65-60 rcl	62.1[bc]
50-30-30	62.1[bc]
50-30-0	61.9[bc]
0-0-30	61.8[bc]
50-0-0	61.4[bc]
0-30-0	60.9[c]

Means in columns with different superscripts are different (P<.05)

Table 5. Three-Year Weighted Average Ca %.

Treatment	% Ca
0-30-0	1.02[a]
0-65-60 rcl	.91[b]
0-0-0	.88[bc]
0-0-30	.86[bcd]
50-30-0	.80[cde]
50-30-30	.77[de]
0-65-60 lesp	.77[de]
50-0-0	.74[ef]
100-65-60	.65[f]

Means in columns with different superscripts are different (P<.05)

Table 6. Three-Year Weighted Average Mg %.

Treatment	% Mg
0-0-0	.33[a]
0-65-60 rcl	.31[ab]
0-30-0	.30[abc]
0-0-30	.29[abc]
100-65-60	.29[abc]
50-30-30	.28[bc]
0-65-60 lesp	.28[bc]
50-30-0	.27[cd]
50-0-0	.24[d]

Means in columns with different superscripts are different (P<.05)

Table 7. Three-Year Weighted Average K %.

Treatment	% K
50-30-0	1.95[a]
50-0-0	1.94[a]
0-65-60 lesp	1.88[ab]
0-65-60 rcl	1.81[abc]
0-0-30	1.76[abc]
50-30-30	1.73[bc]
100-65-60	1.68[c]
0-30-0	1.67[c]
0-0-0	1.63[c]

Means in columns with different superscripts are different (P<.05)

Table 8. Three-Year Weighted Average P %.

Treatment	% P
100-65-60	.23[a]
0-65-60 lesp	.23[a]
0-65-60 rcl	.22[ab]
50-30-0	.19[bc]
50-30-30	.18[cd]
0-30-0	.16[cde]
0-0-0	.16[cde]
50-0-0	.15[de]
0-0-30	.14[e]

Means in columns with different superscripts are different (P<.05)

Table 9. Nutrient Requirements of Selected Classes of Beef Cattle.

Animal Description	CP, %	TDN, %	Ca, %	P, %	K, %	Mg, %
1200 lb. dry cow, mid 1/3 gestation	7.9	54	.26	.17	.60	.12
1200 lb. lactating cow @ 20 pounds of milk	9.8	58	.28	.19	.70	.20
600 lb steer, 1.00 lbs adg	9.3	58	.31	.17	.60	.10
600 lb steer, 1.50 lbs adg	10.6	63	.38	.20	.60	.10
600 lb steer, 2.00 lbs adg	12.1	68	.46	.23	.60	.10

Table 10. Fertilizer Prices by Year, $/lb.

	2007	2008	2009
N	$0.50	$0.90	$0.45
P	$0.34	$1.01	$0.48
K	$0.23	$0.75	$0.67

Table 11. 3-Year Average Yield, Income and Ranking.

Treatment	Yield, lbs. DM / Acre	Yield Rank	Income, $ per Acre	Income Rank
100-65-60	12,630[a]	1	202.46	1
0-65-60 rcl	10,068[b]	2	183.26	2
50-30-30	9,092[bc]	3	155.81	5
0-65-60 lesp	8,737[cd]	4	136.28	9
50-30-0	8,485[cd]	5	150.89	8
0-30-0	8,431[cd]	6	179.83	3
50-0-0	8,101[cd]	7	155.63	6
0-0-0	7,655[d]	8	175.74	4
0-0-30	7,627[d]	9	153.25	7

Table 12. Yield and Income Ranking by Year.

	2007	2007	2008	2008	2009	2009
Treatment	Yield Rank	Income Rank	Yield Rank	Income Rank	Yield Rank	Income Rank
100-65-60	1	1	1	7	1	5
0-65-60 rcl	2	3	2	1	3	4
0-0-0	3	2	9	4	9	3
50-30-30	4	4	3	5	6	8
0-65-60 lesp	5	6	4	8	5	9
50-0-0	6	7	7	9	7	6
0-0-30	7	5	8	6	8	7
50-30-0	8	9	5	3	4	2
0-30-0	9	8	6	2	2	1

Table 13. 3-Year Average Forage Budget - Clifton City Forage Plot

		N only	Synergy	P only	K only	Dealer	Check	Soil Test	Red Clover	Lespedeza
		50-0-0	50-30-0	0-30-0	0-0-30	50-30-30	0-0-0	100-65-60	0-65-60	0-65-60
Estimated Income/Acre										
Total yield	lbs/acre	8101	8485	8431	7627	9092	7655	12,360	10,068	8737
Income/acre	$70.59 per ton*	**$285.92**	**$299.48**	**$297.57**	**$269.19**	**$320.90**	**$270.18**	**$436.25**	**$355.35**	**$308.37**
Fertilizer costs/acre**										
N - Urea (46% N)	$0.617	30.85	30.85	0.00	0.00	30.85	0.00	61.70	0.00	0.00
P - Phosphate	$0.610	0.00	18.30	18.30	0.00	18.30	0.00	39.65	39.65	39.65
K - Potash	$0.550	0.00	0.00	0.00	16.50	16.50	0.00	33.00	33.00	33.00
Application charge	$5.00/acre	5.00	5.00	5.00	5.00	5.00	0.00	5.00	5.00	5.00
Total Fertilizer cost/Acre		***$35.85***	***$54.15***	***$23.30***	***$21.50***	***$70.65***	***$0.00***	***$139.35***	***$77.65***	***$77.65***
Operating costs/acre***										
Crop supplies		5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
Custom hire & rental		13.96	13.96	13.96	13.96	13.96	13.96	13.96	13.96	13.96
Machinery fuel		5.42	5.42	5.42	5.42	5.42	5.42	5.42	5.42	5.42
Machinery repairs & maintenance		5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04
Operator & hired labor		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Operating interest @ 8.42% x 1/2 year		4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92
Total Operating costs/acre		***$42.82***	***$42.82***	***$42.82***	***$42.82***	***$42.82***	***$42.82***	***$42.82***	***$42.82***	***$42.82***
Total Fert. & Operating Costs/Acre		**$78.67**	**$96.97**	**$66.12**	**$64.32**	**$113.47**	**$42.82**	**$182.17**	**$120.47**	**$120.47**
Income Over Fert. & Op. Cost/Acre		**$207.25**	**$202.51**	**$231.45**	**$204.87**	**$207.43**	**$227.36**	**$254.08**	**$234.88**	**$187.90**
Ownership Costs/Acre***										
Farm business overhead		2.68	2.68	2.68	2.68	2.68	2.68	2.68	2.68	2.68
Machinery overhead		8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36
Machinery depreciation		9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20
Real estate charge		31.38	31.38	31.38	31.38	31.38	31.38	31.38	31.38	31.38
Total Ownership Cost/Acre		**$51.62**	**$51.62**	**$51.62**	**$51.62**	**$51.62**	**$51.62**	**$51.62**	**$51.62**	**$51.62**
Total Cost/Acre		**$130.29**	**$148.59**	**$117.74**	**$115.94**	**$165.09**	**$94.44**	**$233.79**	**$172.09**	**$172.09**
Income Over Total Cost/Acre		**$155.63**	**$150.89**	**$179.83**	**$153.25**	**$155.81**	**$175.74**	**$202.46**	**$183.26**	**$136.28**

* = Hay price is on a 100% dry matter basis; based on hay price of $36 per 1200 pound round bale at 85% dry matter.
** = 3-year average of actual fertilizer costs
*** = 3-year average from 2007, 2008 and 2009 FAPRI Fescue/RedClover Hay, Large Round Bale budgets.

ENVIRONMENTALLY SOUND HIGH IMPACT FORAGE MANAGEMENT RESEARCH BASED DEMONSTRATIONS FOR INCREASED LIVESTOCK PROFITABILITY BY INCREASING FORAGE PRODUCTION AND QUALITY

Supplemental and Waste Lime overlay Progress Report

A low management pasture with high visibility was selected for the demonstration site in 2007. The original forage experiment is a replicated split plot design with lime and no lime on the main plots and treatments to include a control check, soil test recommended fertility, a typical retailer recommended pasture fertility package, 30 lbs P only, and 50 lbs N only. The affects of the “Easter” freeze of 2007 has given us concern about the total yield potential and has reduced our legume stand in our establishment year. The legume portion of the plot area was over-seeded with legumes again in 2008 in order to simulate ergovaline dilution recommended practices. In addition to improving data quality in our first study, extending this study an additional year allowed us to add this supplemental experiment that included treatments with Ag lime and various available waste lime products. Generating data by tracking soil pH and plant response (yield and plant composition) of applications of waste lime over time is critical to demonstrating the profitability of applying certified Ag lime materials.

Plots were harvested three times annually to follow annual forage response to management changes and long term economic impact from increased productivity and quality. Forage analysis was conducted on each of the treatments during each harvest to measure forage quality variations in a year round forage production system. Field days were conducted to provide demonstrations of proven research based concepts. These concepts included: soil testing, liming, fertilizer materials, fertilization timing, grazing heights, extended grazing using legumes, grazing frequency, environmental quality and economic benefit of implementing these practices.

2008 Results

Monthly rainfall totals measured 8.36 inches greater than those recorded for the previous year on this same location. April through August rainfall total was greater than the 30 year average. Waste lime was applied on May 7, 2008 to the appropriate plots in this supplemental overlay. Three forage harvests were conducted (May 13, August 5, and November 11). Yearly yield totals reflected an increase of .2 ton/acre in the Agricultural Limestone application when compared to the Waste Lime (10,849 pounds per acre vs. 10,430 pounds per acre respectively). Even with this separation in the year of application, we expect this variation to widen with more reaction time in 2009.

2009 Results

There appears to be no differences in measured parameters in 2008 and 2009. Treatment means do not show large differences in yield or forage quality parameters that would make us believe there were statistical differences. We did not analyze for trace minerals in 2009. Data for 2008 and 2009 are listed in Table 14 and Table 15 below.

Table 14. Yield and Quality Differences Between Waste Lime and Agricultural Lime, 2008 and 2009.

Year	2008							2009					
Harvest date	5-13		8-5		11-4			5-21		8-10		11-2	
Treatment	Waste Lime	Ag Lime	Waste Lime	Ag Lime	Waste Lime	Ag Lime		Waste Lime	Ag Lime	Waste Lime	Ag Lime	Waste Lime	Ag Lime
DM Yield, lbs/acre	4815	5206	3883	3737	1732	1906		5698	5461	3772	3707	2231	2201
CP,%	16.8	16.4	11.1	11.3	9.2	10.1		10.0	9.9	9.3	8.1	9.4	9.2
TDN, %	67.9	66.8	61.7	62.2	67.9	67.6		58.2	58.4	59.1	59.8	63.5	62.1
Ca, %	.68	.66	.67	.70	.71	.83		.41	.40	.80	.66	.63	.59
P, %	.38	.37	.67	.70	.22	.23		.24	.24	.19	.21	.24	.23
Mg,%	.19	.19	.34	.33	.33	.28		.19	.18	.26	.23	.23	.21
K,%	2.59	2.53	1.25	1.25	1.01	1.34		1.95	1.88	1.20	1.44	1.17	1.10
Zn, ppm	23	23	24	29	22	23							
Cu, ppm	9	8	10	13	8	8							
Fe, ppm	117	210	83	91	77	137							
Mn, ppm	79	72	91	63	133	97							

Table 15. Yield and Weighted Average Forage Quality for Waste Lime and Agricultural Lime, 2008 and 2009.

Year	2008		2009	
Treatment	Waste Lime	Ag Lime	Waste Lime	Ag Lime
DM Yield, lbs/acre	10,430	10,849	11,701	11,369
CP, %, wt. avg.	13.4	13.5	9.7	9.2
TDN, %, wt. avg.	65.6	65.4	59.5	59.6
Ca, %, wt. avg.	0.68	0.70	0.58	0.52
P, %, wt. avg.	0.46	0.46	0.22	0.23
Mg, %, wt. avg.	0.27	0.25	0.22	0.20
K, %, wt. avg.	1.83	1.88	1.56	1.59
Zn, ppm, wt. avg.	23	25		
Cu, ppm, wt. avg.	9	10		
Fe, ppm, wt. avg.	98	156		
Mn, ppm, wt. avg.	92	73		