EFFECT OF ALFALFA STAND DENSITY OR CUTTING MANAGEMENT ON NITROGEN SUPPLYING CAPACITY

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Introduction

Economic, energy and environmental considerations are making the efficient use of nitrogen fertilizers increasingly important for Wisconsin crop producers. Excessive nitrogen applications cannot be tolerated environmentally due to the potential for N leaching to groundwater, or economically due to the relatively high cost of N fertilizers.

The potential exists for many producers, farming in legume rotation, to unknowingly over-apply N by not fully applying credits for previously grown alfalfa. A 1985 CAST report suggests that properly managed legumes may replace 25 to 50% of the N needs for field crops. The current University of Wisconsin recommendation for plowed down alfalfa is 40 lb/a N plus 1 lb/a N for each percent stand. For good stands (>50%) a second year credit of 30 lb/a N is given (Kelling et al., 1981). A recent survey of North Central extension specialists showed a wide variation in credits for alfalfa (Table 1). Several states do not offer any credit in the second year. These differences suggest that more research is necessary across a wider range of conditions to more precisely assess alfalfa nitrogen credits.

Research data show that a full stand of alfalfa can supply nearly all the nitrogen that a succeeding crop of corn needs (Higgs et al., 1976). Heichel et al. (1981) estimated that incorporation of a lush stand of alfalfa may add up to 190 lbs of fixed nitrogen. However, based on mass balance studies, Heichel and Barnes calculated that incorporation of only the stubble after harvest may not increase the nitrogen status of the soil. Thus, it is clearly necessary to understand the effects of stand characteristics and density, and previous harvest management so that accurate nitrogen credits can be awarded and most efficient use made of applied nitrogen fertilizers.

This study was established to evaluate: 1) the relationship between alfalfa stand characteristics (stand density as visual rating of percent stand or as plants/ft^2) and its ability to supply N to a succeeding corn crop; and 2) the effects of various alfalfa harvest management options on the N supply to a succeeding corn crop.

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Table 1. Alfalfa nitrogen credits for several North Central states*.

State	Condition**	First Year	Second Year
		------------lbs N/a------------	
Illinois	Full	100	40
	Other	60	0
Indiana	4 plants	80	0
	<4 plants	40	0
Iowa	Full	140	50
	0-50%	80	30
Kansas	Full	125	50% of first year
	50%	60	
	0%	0	
Michigan	Any	(.6)x(% stand)+40	0
Minnesota	Full	150	50% of first year
	Poor	75	
Missouri	Good	100	50% of first year
	50%	50	
Nebraska	Full	100	0
	50%	50	0
North Dakota	Any	40	0
South Dakota	>3 plants	100	50% of first year
	1-3 plants	50	
	<1 plant	0	

* Data collected at the North Central Fertility Workshop, St. Louis, MO, 30 October 1987.

**Plants = number of plants per square foot.

Materials and Methods

In 1988 and 1989, field plots were established at the Arlington, Lancaster and Hancock Agricultural Research Farms on 2-3 year-old established alfalfa fields to evaluate alfalfa stand density or cutting management on the ability to supply N to a succeeding corn crop. Four levels of alfalfa stand density (initial stand density, approximately 2/3 and 1/3 of initial density and zero alfalfa) and four alfalfa harvest schemes (two cuttings pre-August, three cuttings pre-September and four cuttings pre-frost, all with fall tillage; and three cuttings pre-September with spring tillage) were created as two separate experiments in 1988. The plots were harvested as hay throughout fall of 1988 and plowed in late October. Separate but similar plot areas were established at each location in 1989 for planting to corn in 1990.

The various stand densities were created by using 4' x 18' x 1/4" plywood templates with 33 or 67% of the ground surface area exposed. The template was moved across the plot area and the openings were sprayed with a 2% solution of the non-selective herbicide "Roundup", as well as the whole surface area for the 0% stand plots. The 100% stand plots were left untreated. Crown counts were taken by averaging the number of crowns within three randomly placed 1 ft^2 frames. Visual stand ratings were made by averaging 3-5 individual estimates of percentage of the plot covered by alfalfa.

As early as possible in the spring of 1989, and similarly in 1990, composite soil samples were taken from the 1988 or 1989 hay plots to a 3-5 ft depth and analyzed for NO_3-N and NH_4-N. Corn was then planted to provide a final population of 26,000 to 28,000 plants/a. Starter fertilizer (6-24-24) was applied in a 2" x 2" placement at a rate of 200 lb/a. Various N rates (0, 50, 100 and 150 lb N/a) were superimposed as subplots on the main plot areas. All plots were treated uniformly with a standard herbicide as dictated by weed pressure for the particular field.

The superimposed nitrogen rate treatments were applied by hand banding NH_4NO_3 (34-0-0) about 4-6" to the side of each row when the corn was 12-15" inches. The corn was cultivated after sidedressing. Whole plant yields were measured at physiological maturity, grain yields were measured in mid-October. Subsamples of silage or grain were also taken for gravimetric moisture determination and were analyzed for total Kjeldahl nitrogen.

Results and Discussion

Stand Density Experiment

Table 2 shows the stand densities created by the partial or total spraying with glyphosate. Clearly the differential spraying resulted in differences that were more or less in the range desired, and the actual stand counts tended to reflect these differences somewhat better than did the visual ratings. In 1988 the very dry year resulted in some stand deterioration (15-20%) during the growing season (data not shown). This trend was not seen during 1989.

Table 2 also shows the effects of stand density on alfalfa yields in 1988 and 1989. In general, 1989 yields were lower than those of 1988 due to continued dry weather and lack of moisture reserves. For all individual cuts and total yield at all locations, there are significant differences in yields between the four stand density treatments with increasing stand density resulted in increased yield. Yields from the 0 alfalfa plots were not taken in 1988, but when they were harvested in 1989 it is apparent significant dry matter from grasses and annual weeds were produced on these plots. Most of this yield was taken at third cutting. Minor differences were seen in alfalfa tissue N concentrations (data not shown) but the obvious influence of treatment on N uptake is primarily the result of increased yields associated with the higher stand densities.

Table 2. Effect of herbicide treatments on created alfalfa stand densities, yield and N uptake at three Wisconsin locations 1988.

Desired stand	1988 Actual Stand plt count	1988 Actual Stand visual rate	1988 Forage* yield	1988 N uptake by forage	1989 Actual Stand plt count	1989 Actual Stand visual rate	1989 Forage* yield	1989 N uptake by forage
%	plt/ft^2	%	T/a	lb/a	plt/ft^2	%	T/a	lb/a
				Arlington				
0	0.0	0	--	--	1.1	7	1.30	
33	2.8	61	2.09	140	2.2	46	1.39	
66	3.5	58	2.84	189	2.4	59	1.41	
100	5.4	72	3.90	252	3.3	75	2.04	
				Lancaster				
0	0.0	0	--	--	0.0	3	1.54	
33	1.2	26	0.96	57	0.6	16	1.52	
66	2.2	41	1.34	82	1.4	32	1.65	
100	4.2	58	3.17	200	5.0	75	2.65	
				Hancock				
0	0.0	0	--	--	0.1	2	1.63	
33	1.8	45	2.24	118	1.6	62	1.88	
66	3.2	48	2.90	165	2.8	71	3.07	
100	4.5	87	3.87	235	5.1	98	3.24	

*3 cuttings

The effect of nitrogen rate and previous year alfalfa stand density on silage and grain yields of corn for 1988 are presented in Table 3. There were no significant differences in silage or grain yields due to stand density or N rate at Arlington. This may have been partly due to the inherent nitrogen supplying power of this 3.5-4% organic matter soil. Spring profile nitrate-N levels ranged from 50-120 lb/a in the top 4 feet. It is also possible that the effects of the drought of 1988 may have had some carryover effect as April to September precipitation was 4.4 inches below normal; however, overall the excellent yields somewhat argue against this possibility.

At Lancaster, stand density was inversely related to silage and grain yields, most likely due to a moisture conservation in the less dense stands. The drought of 1988 probably resulted in substantially greater moisture use at the higher plant densities which, in turn, resulted in lower moisture reserves in these plots in 1989. The influence of the 1988 drought was most evident at this location since 1989 was also quite dry at this site (Apr-Sept 89 precipitation was 5.09 inches below normal). Nitrogen at Lancaster accounted for some tendency in improvement of silage yields and N uptake with increasing N rate; however, this too was likely confounded by the moisture deficit.

Table 3. **Main effect of previous-year alfalfa stand density and N rate on corn silage yield and N uptake and grain yield at three Wisconsin locations, 1989.**

Treatment	Arlington			Lancaster			Hancock		
	Silage yield	Silage uptake	Grain yield	Silage yield	Silage uptake	Grain yield	Silage yield	Silage uptake	Grain yield
	T/a	lb/a	bu/a	T/a	lb/a	bu/a	T/a	lb/a	bu/a
Desired Stand density, %									
0	9.0	205	199	7.7	221	140	8.1	168	164
33	9.0	211	188	7.3	211	123	8.2	165	171
66	9.4	228	192	6.7	188	120	8.4	175	177
100	9.0	225	190	6.7	192	108	9.1	207	190
LSD.05	NS	NS	NS	0.9	NS	14	NS	28	11
N rate, lb/a									
0	9.0	219	195	6.9	187	121	6.8	128	142
50	9.0	219	194	7.1	205	125	8.8	179	179
100	9.3	213	194	6.8	197	124	9.1	195	191
150	9.1	217	187	7.7	222	122	9.1	213	193
LSD.05	NS	NS	NS	0.7	20	NS	0.6	26	7
Pr>F									
Density	0.76	0.51	0.14	0.07	0.09	0.01	0.06	0.03	0.00
N rate	0.67	0.96	0.22	0.03	0.01	0.88	0.00	0.01	0.00
NR x density	0.39	0.13	0.54	0.09	0.16	0.46	0.28	0.47	0.00

*Stand densities created in spring 1988, N treatments sidedressed to corn 1989.

Both stand density and N rates were significantly related to silage and grain yields at the irrigated Hancock location, with the highest yields resulting from the highest stand density and up to the second highest N rate. If moisture had been adequate during 1988 and through 1989, it may be speculated that the results at Arlington and Lancaster would be more similar to those at Hancock since stand density directly affected alfalfa yields at all three locations. However, the 1990 silage yields for the three locations do not confirm this hypothesis (Table 4). Statistics are not provided as these data are still very preliminary. Rainfall was adequate throughout the growing season at all locations. Although there is a tendency for higher silage yields at the higher stand densities, this relationship is not as distinct as expected. An additional stand density experiment was created at each location in 1990 which will be planted to corn in 1991.

In some cases, the interaction between N rate and stand density was highly significant. For example, Figure 1 shows this interaction for grain yield at Hancock in 1989. It is apparent that for the 0 and 50 lb/a N rates stand density dramatically influenced yield, but at the two higher N rates stand density was not important. Within each stand density substantial response to N was seen at the two lower density levels, but less so (except for the 0 N rate) at the higher densities. In contrast to trials with soybeans (Bundy and Wolkowski, 1986) these data show that fall tilled forages can result in N credits on these irrigated sands.

Table 4. Main effect of previous-year alfalfa stand density and N rate on corn silage yield at three Wisconsin locations, 1990.

Treatment	Arlington	Lancaster	Hancock
		T/a	
Desired Stand Density (%)			
0	9.6	8.4	7.9
33	10.6	8.5	9.0
66	10.8	8.2	8.5
100	10.3	8.7	8.2
N Rate (lb/a)			
0	9.8	8.5	6.5
50	10.2	8.5	8.3
100	10.4	8.5	9.1
150	10.7	8.2	9.9

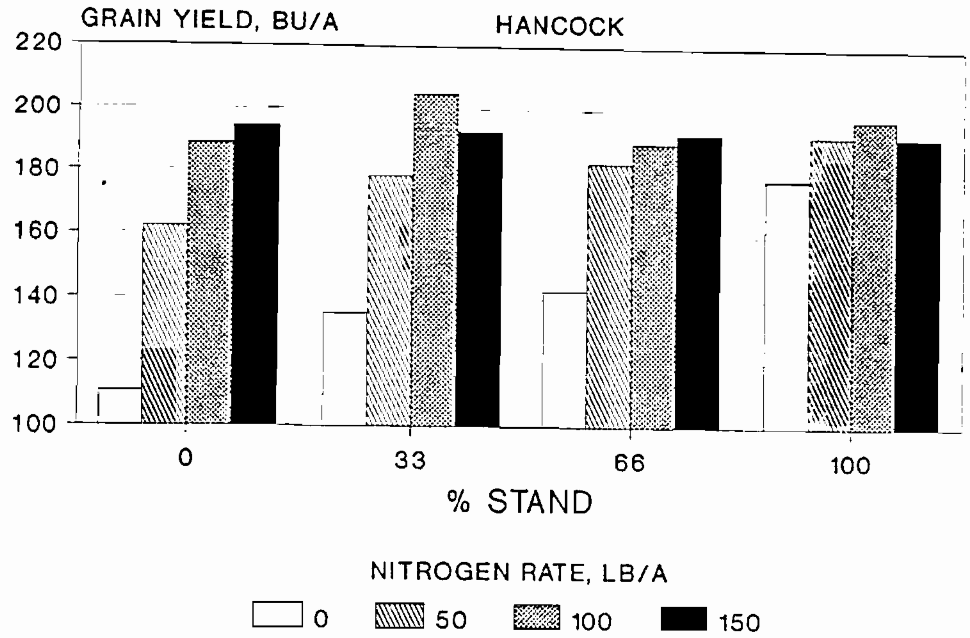

Figure 1. Interaction of previous alfalfa stand density and sidedressed applied N on corn grain yield at Hancock, WI, 1989.

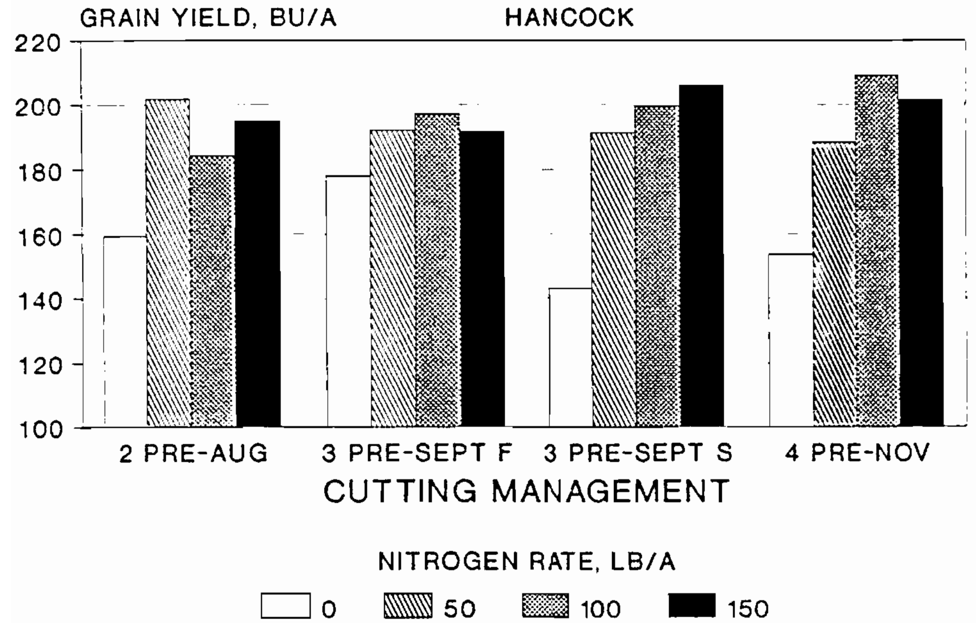

Figure 2. Interactive effects of N rate and previous alfalfa cutting management on corn grain yield at Hancock, WI, 1989.

Harvest Management Experiment

The results of the 1988 and 1989 alfalfa yields for the harvest management comparison are presented in Table 5. Obviously, within each of the individual cuts, cutting management did not result in significant yield differences since the only treatment differences were the number of cuttings (data not shown). The obvious effects of the drought of 1988 and continued dry weather in 1989 were particularly evident for cuts 2-3 for the later cuts in 1988 and early cuts in 1989. All yields were lower than would be expected in seasons of adequate rainfall. The total yields of the various treatments are different, however, with the 2-cut treatment yielding the lowest and the 4-cut treatment the highest. It is then expected that the 2-cut treatment returned the most vegetative matter to the soil; the 4-cut treatment the least.

Table 5. Effect of forage cutting management on alfalfa dry matter yields at three Wisconsin locations, 1988 and 1989.

Cutting	1988			1989		
management*	Arl.	Lan.	Han.	Arl.	Lan.	Han.
	T/a DM					
3 Pre Aug	3.27	2.17	2.49	1.42	1.80	2.27
3 Pre Sep F (fall tilled)	3.74	3.04	3.47	2.00	2.65	3.24
3 Pre Sep S (spring tilled)	3.77	2.68	3.54	2.05	2.61	3.30
4 Pre Nov	4.21	3.63	4.00	2.92	3.29	3.73

* Number of cuttings taken before indicated month in 1988 or 1989.

The significant interaction between N rate and cutting management for grain yield is illustrated in Figure 2. From these data it would appear that less response to added N was apparent where more organic matter was returned to the soil and where more time was allowed for mineralization (fall versus spring tillage). These data tend to support the silage results even though the main effect of cutting management was not significant for grain yield.

Results of silage yields for 1990 also tended to show lower yields associated with total forage dry matter removal (4 cuttings). Results for the spring versus fall tillage comparison, however, tended to favor spring tillage in this year. This may be partly due to the somewhat wetter condition in spring and early summer of 1990 leading to greater N losses where the N had mineralized more completely.

Table 6 shows the effects of N rate and 1988 alfalfa cutting management on corn silage yield and uptake and grain yields in 1989. At all three sites, cutting management did not affect corn grain, and only at Hancock was silage yield affected by cutting management, however the interaction was significant or nearly so at all of the locations for one or more parameters. At Hancock the silage yields generally increased with the amount of organic matter returned the soil and the amount of time available for mineralization.

Table 6. Main effect of nitrogen rate and previous year alfalfa cutting management on corn silage dry matter and grain yields at three Wisconsin locations, 1989.

	Arlington			Lancaster			Hancock		
Cutting Mgmt. Treatment	Silage yield	Silage uptake	Grain yield	Silage yield	Silage uptake	Grain yield	Silage yield	Silage uptake	Grain yield
	T/a	lb/a	bu/a	T/a	lb/a	bu/a	T/a	lb/a	bu/a
Cutting Management									
2 Pre Aug	8.8	220	193	6.5	184	114	9.6	231	182
3 Pre Sept F	9.0	224	190	6.7	192	108	9.1	207	190
3 Pre Sept S	9.4	230	202	6.4	182	112	8.8	189	195
4 Pre Nov	9.1	226	187	6.9	196	118	8.8	213	187
LSD.05	NS	NS	8	NS	NS	NS	NS	NS	NS
N rate, lb/a									
0	9.3	222	191	6.4	173	110	7.9	170	159
50	9.1	219	194	6.5	188	123	9.3	204	191
100	8.8	222	194	6.8	194	114	9.7	221	197
150	9.2	237	193	6.8	198	108	9.5	244	200
LSD.05	0.5	NS	NS	NS	NS	NS	0.5	32	9
Pr>F									
Cutting Mgmt.	0.33	0.69	0.01	0.69	0.89	0.33	0.18	0.53	0.28
N rate	0.23	0.60	0.83	0.49	0.08	0.11	0.00	0.00	0.00
NR x CM	0.16	0.13	0.81	0.02	0.08	0.71	0.24	0.70	0.02

Table 7. Main effect of cutting management and N rate on corn silage yield at three Wisconsin locations, 1990.

Treatment	Arlington	Lancaster	Hancock
	------------------T/a------------------		
Cutting Mgmt.			
2 Pre Aug	10.4	8.6	8.9
3 Pre Sep F	10.0	8.7	8.2
3 Pre Sep S	10.6	8.8	8.6
4 Pre Nov	9.9	8.5	7.5
N Rate (lb/a)			
0	9.6	8.8	6.5
50	10.0	8.5	8.2
100	10.7	8.9	8.9
150	10.6	8.5	9.6

Summary

Alfalfa yields and thus the amount of organic matter returned to the soil after alfalfa is grown depends on both the stand density and the number of cuttings taken, with these differences appearing in both years of the study. In 1989 and 1990 these differences were clearly translated into different amounts of N made available for the following year's crop at Hancock, but had less obvious effects at the other two sites. Low soil moisture in 1988 and much of 1989 most likely contributed greatly to the lack of response to previous year alfalfa treatments at Lancaster and Arlington. It is also possible that even very poor stands of alfalfa contribute adequate N for first year corn.

Where responses were seen, in general, they were about as expected with little response to added N (certainly no response above 50 lbs) for the full stand, but substantial responses to at least 100 lb N/a at the lower stand densities. Similarly, the previous cutting management influenced the responsiveness to added N with less response where larger amounts of alfalfa N was incorporated. It must be remembered that these data are for only one year and part of the second and need to be confirmed by additional years of experimentation. This trial will be continued in 1991.

Literature Cited

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Kelling, K.A., P.E. Fixen, E.E. Schulte, E.A. Lingel and C.R. Simson. 1981. Soil test recommendations for field vegetable and fruit crops. UWEX Fact Sheet A2809. 30 p.

Wisconsin Research in Soil Fertility

The following soil fertility and plant nutrition research is currently being conducted by, or in cooperation with, personnel in the Department of Soil Science, University of Wisconsin, Madison.

Improving N Management

Effect of long-term N treatments on corn response to soil and applied N. L.G. Bundy.

*Evaluation of soil and plant tests for site-specific prediction of corn nitrogen fertilizer requirements. L.G. Bundy and T. Andraski.

Prediction of nitrogen availability in long-term crop sequences. L.G. Bundy, M. Vanotti, A. Peterson.

Use of petiole NO_3 for determining potato N needs. K.A. Kelling.

*Determination of legume N credits as affected by stand density and last-hay-year management. K.A. Kelling, J.K.D. Jarman, R.P. Wolkowski.

Evaluation of corn genotype response to nitrogen. L.G. Bundy and T. Andraski.

*Impact of forage legumes on potato production. C. Grau and K.A. Kelling.

Evaluation of potato and sweet corn needs on organic soils. K.A. Kelling and K. Clausen.

Alfalfa N credits to corn grown under different tillage systems. R.P. Wolkowski.

Effect of sampling time on soil profile nitrate content. R.P. Wolkowski.

*Nitrogen fixation and rotational benefits of soybean grown in rotation with corn. E.S. Oplinger and P.R. Carter.

*Nitrate movement through the unsaturated zone of a sandy soil in the lower Wisconsin River Valley under irrigated conditions. B. Lowery.

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*Research supported in part by The Wisconsin Fertilizer Research Council by a tonnage assessment on fertilizer

Soil Acidity and Liming

Effect of aglime on crop yield and quality. E.E. Schulte, J.B. Peters, K.A. Kelling.

Use of flyash as a liming material. E.E. Schulte and W.R. Kussow.

Interaction of pH and nitrogen on alfalfa establishment, growth and quality. K.A. Kelling and J.B. Peters.

Crop Responses to Applied Nutrients

Effect of soil compaction on corn hybrid response to soil K level and row-applied K. L.G. Bundy and R.P. Wolkowski.

*Practical means for enhancing Ca content of potato tubers. J. Palta.

*Evaluation of phosphorus availability and accumulation in potatoes as affected by mycorrhizae, soil test and fertilizer additions. K.A. Kelling, R.B. Corey, J.L. Iyer, W.R. Stevenson.

*Late season fertilization of soybeans. E.S. Oplinger.

*Calibration of soil tests for alternative crops. E.E. Schulte.

*Foliar applied boron effects on alfalfa morphology nutritive value and yield. K.A. Albrecht.

*Corn yield and economic benefits from starter fertilizer use at various planting dates. L.G. Bundy, P. Widen, E.E. Schulte.

Turfgrass nutrition

Influences of N sources and rates on the invasion of creeping bentgrass turf by *Poa annua*. W.R. Kussow.

*Significance of fall and dormant N in turfgrass management. W.R. Kussow.

Response of Kentucky bluegrass to Milorganite formulations. W.R. Kussow.

Role of Fe in turfgrass culture. W.R. Kussow.

Product evaluations

Use of a urease inhibitor to improve the efficiency of surface-applied urea-containing fertilizers. L.G. Bundy.

Evaluation of liquid 0-0-20 as a potash source for corn. E.E. Schulte.

*Evaluation of certain nonconventional soil additives. K.A. Kelling, R.P. Wolkowski, E. S. Oplinger.

Other

Development of software for integrated crop management of potatoes. W.R. Stevenson, L.K. Binning, D. Curwen, K.A. Kelling, J.A. Wyman.

*Economic and yield of grains as influenced by crop rotation systems. E.S. Oplinger and P.R. Carter.

*Use of non-conventional herbicide/fertilizer combinations for improved weed control, fertilizer management, and profitability. R.G. Harvey.

*Evaluation of DRIS analysis for predicting corn response to Ca. E.E. Schulte and J. Baldock.

*Improving fertilizer placement in CT systems. K. Shinners.

*Effect of chemical and cropping system management on soil aggregation and microbial ecology. R.H. Harris.

*Nutrient monitoring in the Wisconsin cropping system trial. J. Posner.

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