THOMPSON

AGRICULTURE

ALTERNATIVES

2009 REPORT

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FERTILITY

Historical information on the nutrient budget, as well as leaf tissue and soil analyses, is presented in the following figures and tables.

Figure 2-1 shows the amount of nutrients removed and added during the 5 year rotation. The city bio-solids and purchased supplements are bringing on the farm more phosphorus than the system is shipping off in grain and livestock **(Table 2-1).** The amount of nutrients removed by crops is found in **Table 2-2.** Analysis of the manure/bio-soilids is shown on **Table 2-3. Figure 2-2** shows how the nutrients added are calculated from **Table 2-3.** There is more nitrogen and potassium removed than replaced by manures. So far, additional nitrogen and potassium have not increased crop yields. Most of the crop residues are removed for feed or bedding and then returned to the fields as manure. The amounts of manure and purchased fertilizers used to meet the crop needs are discussed later.

The pH has varied from 6.6 to 8.0 during the period from 1967 to 1991. The high pH of 8.0 came during the composting practice **(Figure 2-3 & Table 2-4)**. The high pH soils in the low areas have reduced yields.

The calcium and magnesium soil tests are shown in pounds per acre **(Figures 2-4 and 2-5).** The calcium range is from 4130 to 7680 pounds per acre, and the magnesium ranges from 641 to 966 pounds per acre **(Table 2-4).** It is hard to explain why the calcium and magnesium soil tests are going down when cement kiln dust (CKD) is adding more calcium and magnesium. The CKD addition has been reduced in 1997 when the Boone waste water treatment plant was changed to the aerobic digestion process.

Corn ear leaf samples were first collected in 1984 and were found low in nitrogen and potassium. In most years, when nitrogen values increased the potassium values went down **(Figure 2-6 & Table 2-5)**. Corn ear leaf potassium has not increased during these years with the purchase of

Nutients Added During 5 Year Rotation
11.84 Dry Tons (23680#) Per Acre

Nitrogen	P2O5	K2O
23680	23680	23680
X 3.08%	X 1.06%	X 1.22%
729#N/A.	251# P/A.	289# K/A.
- 116 N loss	X 2.29 factor	X 1.2 factor
613 N/A.	575# P2O5/A.	347# K2O/A.

Figure 2-2

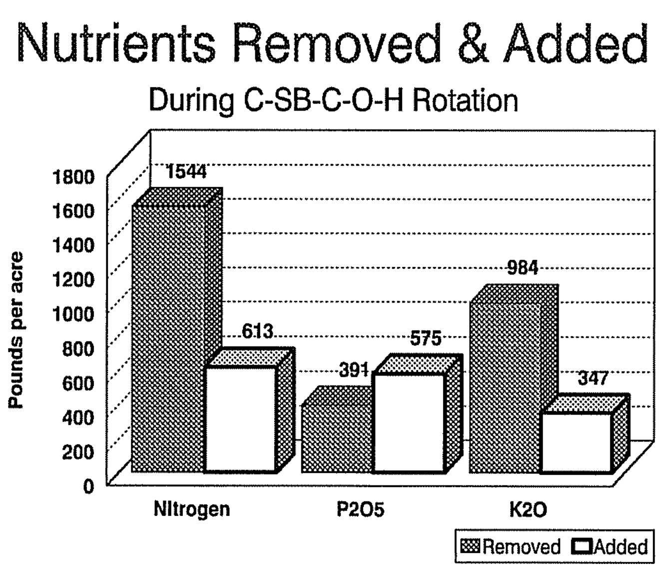


Figure 2-1

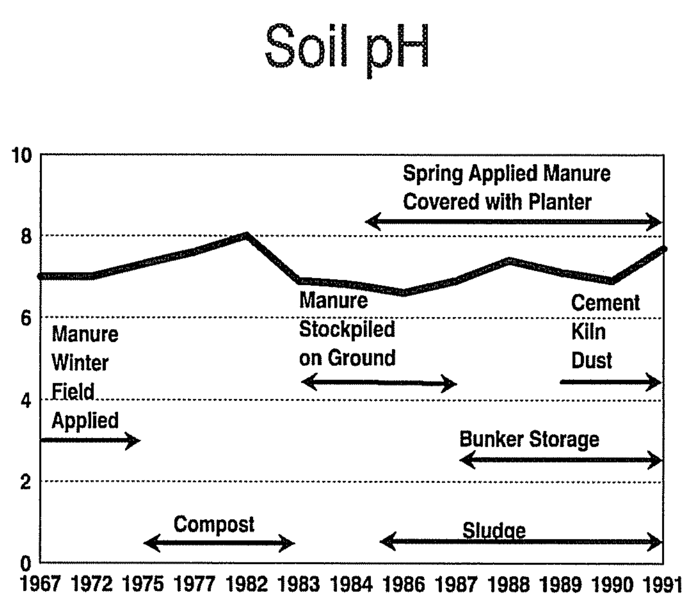


Figure 2-3

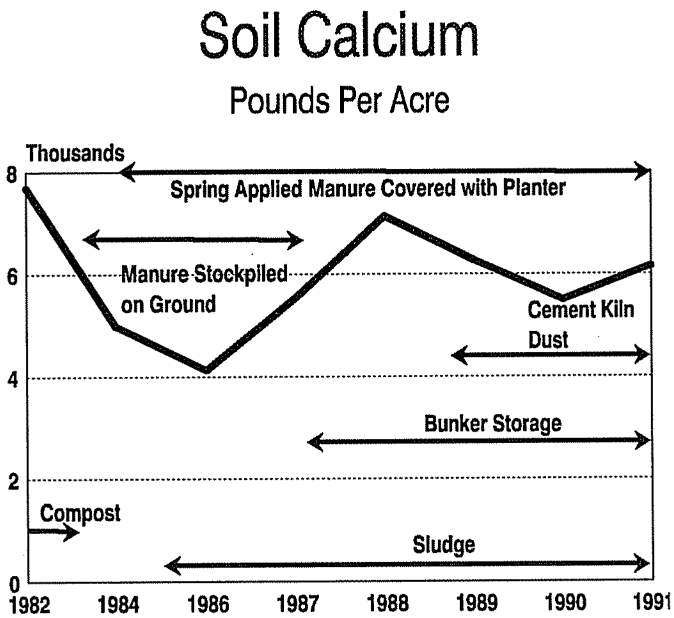


Figure 2-4

potassium fertilizer or with the addition of cement kiln dust to stabilize city bio-solids. The crops, especially corn, could not take in the potassium because the fertiliity was too close to the soil surface. The potassium ear leaf did increase in 1994 following the moldboard plow tillage **(Table 2-5 & Figure 2-6).**

Nitrogen

The mid-June soil nitrate nitrogen levels have been close to the desired range of 20 to 25 parts per million since 1987 in our manure system**(Figure 2-7).**

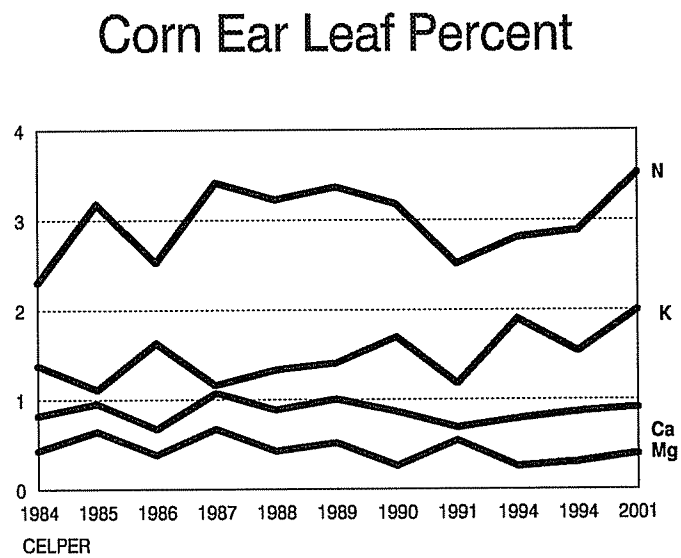


Figure 2-6

Five nitrogen trials conducted over the three year period of 1987-1989, found no significant increases in corn yield from side dressing nitrogen at first cultivation **(Figure 2-8 & Table 2-8).** The side dress nitrogen rate ranged from 50 to 84 pounds per acre. These results show that a 20 to 25 ppm soil nitrate level is adequate for corn production. The corn yields for all treatments should be higher, but low potassium uptake limited corn yield.

Practical Farmers of Iowa has put a great deal of effort into using the late spring soil nitrate test as a tool to help the farmer to identify whether or not it is possible to use less nitrogen fertilizer. Results from 63 trials conducted by PFI cooperators over a

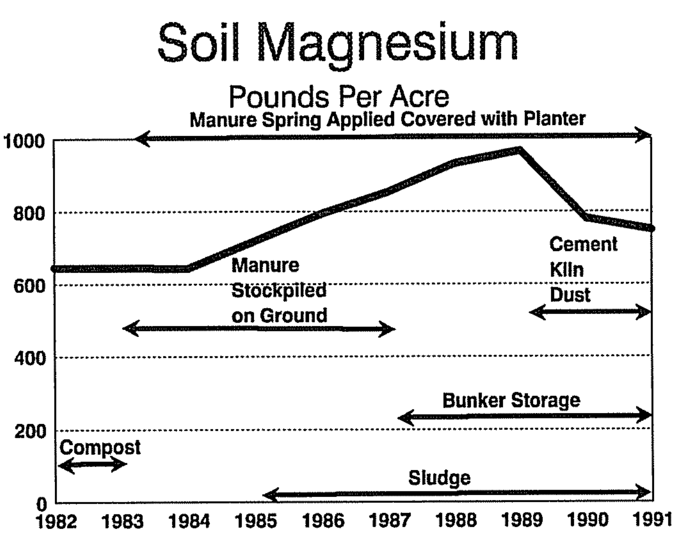


Figure 2-5

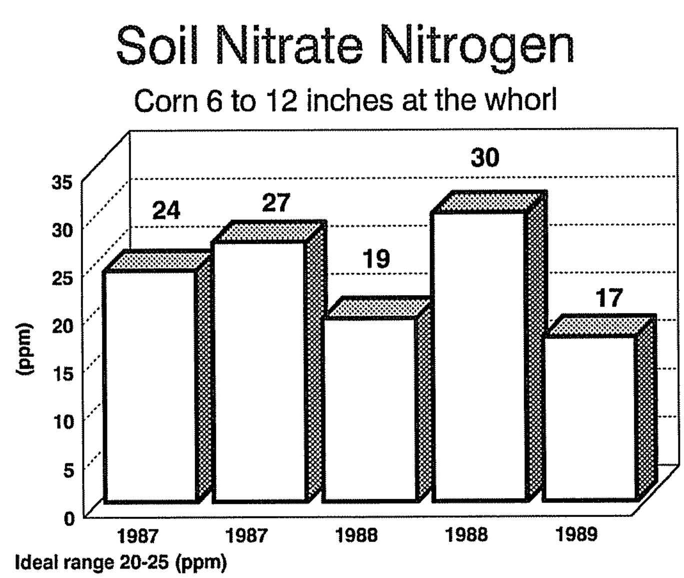


Figure 2-7

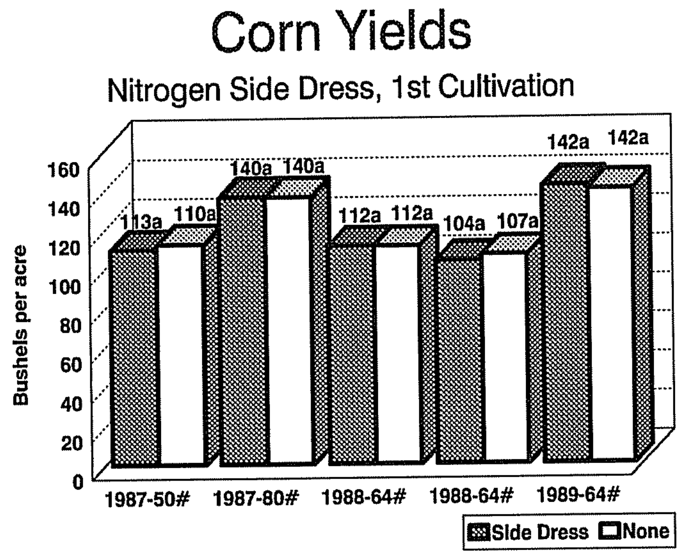


Figure 2-8

five-year period from 1987 through 1991 have been very consistent.

Using the late spring soil nitrate test, cooperators on the average reduced purchased nitrogen applied to their corn crops by 54 pounds per acre **(Figure 2-9).** The actual amounts of applied nitrogen ranged from 0 to 130 pounds, compared to the customary range of 60 to 190 pounds per acre.

There are enormous economic and environmental implications for Iowa if corn farmers were to use one of the available late spring tests to fine tune their nitrogen nitrate applications on all of Iowa's corn acreage.

There are 10.7 million acres of corn grown in Iowa each year. Research conducted by PFI cooperators found that, on the average, farmers could have used 54 fewer pounds of nitrogen per acre. If we consider that it takes 1 gallon of diesel fuel to produce 5.34 pounds of nitrogen, it would have been possible to save the equivalent of 110 million gallons of diesel fuel, or $82,000,000, based on 1990 prices.

The key point is that we now have a tool to help us make decisions on the amount of nitrogen to apply. Less nitrogen applied to the land will result in less nitrogen in the water table. Less money spent by the farmer to purchase nitrogen will mean more money in the farmers' pocket.

We are pleased to note that the practice of using the Blackmer test has spread beyond the farms of members of Practical Farmers of Iowa. In 1989, 16 fertilizer dealers across Iowa began to use the late spring nitrate test. Nitrogen rates were reduced by 76 pounds per acre while the corn yields remained the same. This is a win/win situation for the environment and farmer profitability. Unusually wet conditions like we experienced in the spring and summer of 1990 will show a different type of return that can result from the use of the late spring nitrogen tests. High rainfall will cause leaching, and many farmers will need to apply more supplemental nitrogen than needed in dryer years. Therefore, the savings on nitrogen may not be as great in wet years

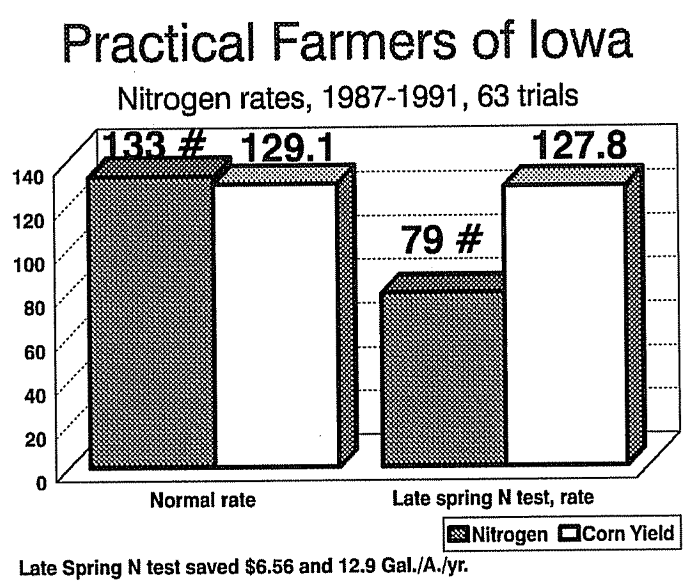


Figure 2-9

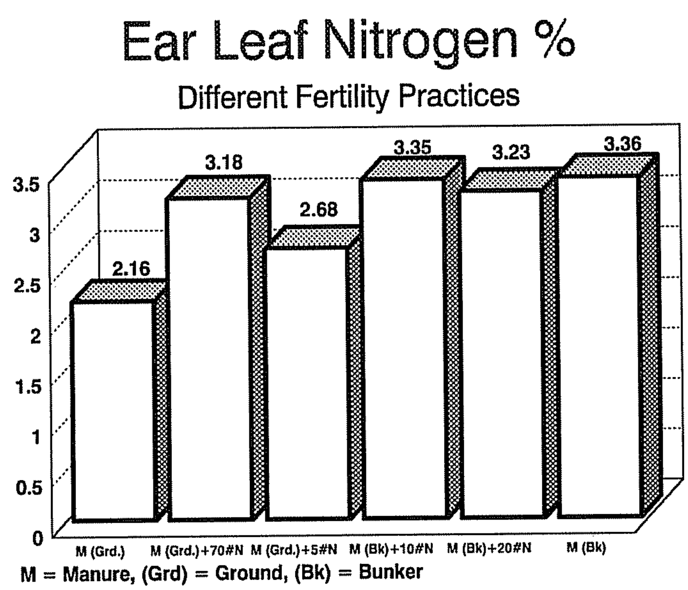


Figure 2-10

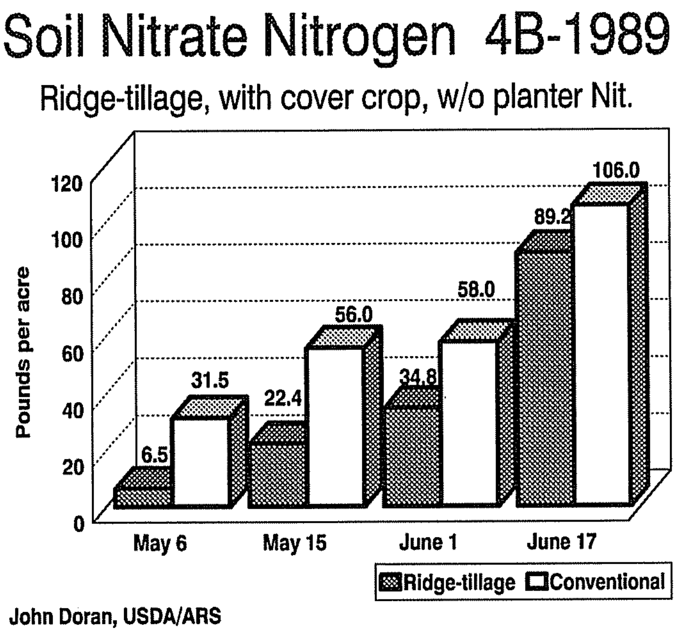


Figure 2-11

as they are in dry years. For example, the average amount of nitrogen saved in 1990 in PFI cooperator trials was 46 pounds per acre, while in the dry year of 1989 the average was 57 pounds. Thus, the soil nitrate tests helps the farmer apply the right amount of nitrogen in both wet and dry years. The test also means the right amount of nitrogen will be applied on each individual field rather one rate for all fields. There is a good possibility that total yields will be higher than they would have been if all fields had received the same amount of side dressed supplemental nitrogen. It is evident the net return will be higher by using the proper amount in each field.

Since the installation of the cement manure bunker at the Thompson farm, the ear leaf nitrogen rose to 3.35 percent in 1987 and has remained in the desired range with an additional 10 to 20 lb/A of planter applied nitrogen **(Figure 2-10)**.

Although ear leaf nitrogen is more than adequate (2.75 to 3.0 percent is ideal), does not mean there was adequate nitrogen for the corn plant in May and June. Research work done by John Doran (USDA/ARS) in field 4B; shows covered, undisturbed soil, without manure, to be much lower in nitrate nitrogen in May and June than soil that was conventionally (mulch) tilled **(Figure 2-11)**.

Doug Karlen (USDA/NSTL) found the same trend in the alternative/conventional study. The nitrogen levels were lower in the young plant and the ear leaf samples in the alternative system of ridge tillage, rye cover and spring manure **(Figure 2-12 and 2-13)**. The alternative/conventional study is explained in greater detail in the water quality-soil health section (Chapter 6).

Residue Management

Fields that are going to corn and oats with heavy surface residue will need 20 to 50 lb/A of nitrogen at planting. Heavy cornstalk residue is very competitive with oat production. Heavy rye residue is very competitive for corn. If no-till and

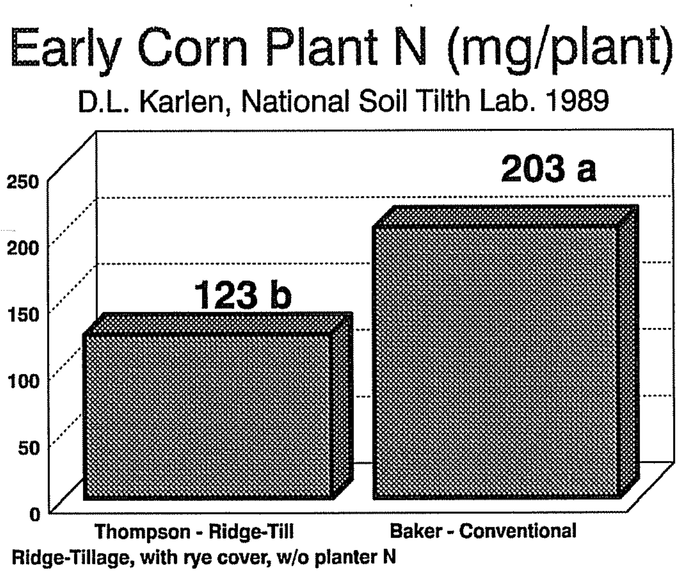


Figure 2-12

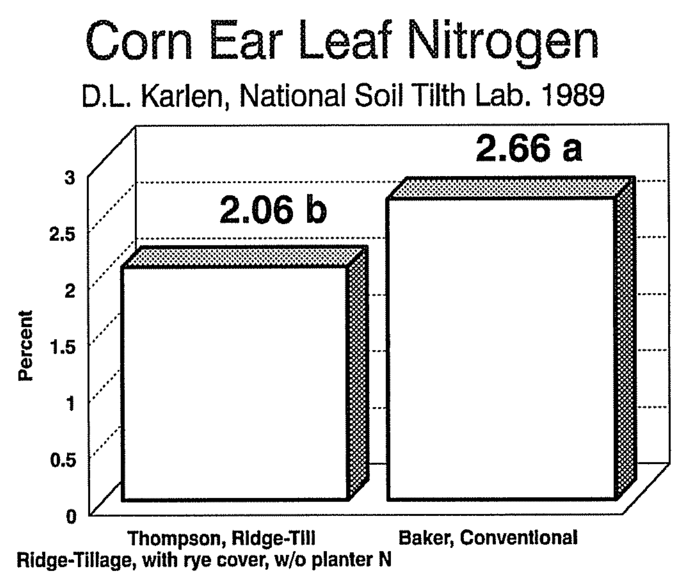


Figure 2-13

ridge-till are included, additional early nitrogen will be needed.

Cornstalk removal for cow feed prior to oat planting helps to two ways. 1. Added income to the corn crop 2. Reduced nitrogen tie-up.

Phosphorus

The P_1 soil test readings are shown in **Figure 2-14 & Table 2-4**. In 1967 the reading was 9 ppm and the reading for 1989 was 66 ppm. The Phosphorus Balance Sheet chart **(Figure 2-15 & Table 2-1)** shows the same soil test readings on the black line, while the gray line shows the amount of phosphorus added or subtracted per acre per year. The phosphorus left the farm through animals sold for meat and phosphorus came on the farm through grain, supplements and city bio-solids.

During this 24 year time period 264 pounds per acre of elemental phosphorus had been added. The amount of P_2O_5 added would be 605 pounds per acre (P times 2.29 = P_2O_5). It takes about 9 pounds of P_2O_5 to raise the P_1 soil test 1 pound. The 605 pounds per acre of P_2O_5 divided by 9 should raise the soil test 67 pounds per acre. The 1967 reading of 19 plus 67 equals 86. The latest readings average 102, a difference of 16 pounds per acre.

This difference is probably do to three factors: 1) the 9 to 1 ratio is an average factor and may not represent this soil; 2) the phosphorus additions were through manure and there is some data that would indicate that the organic fraction of phosphorus will raise the soil test faster; 3) the rotation contains deep rooted legumes that pull up phosphorus from lower levels and the residue is left near the surface and would be picked up by the soil test.

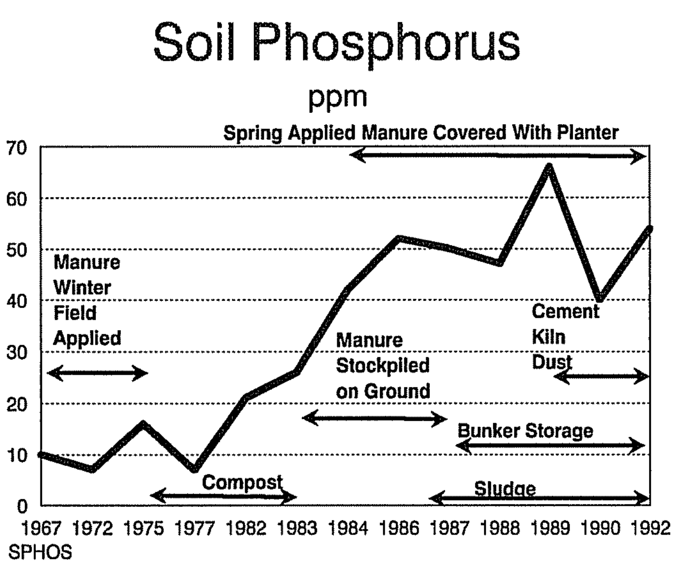


Figure 2-14

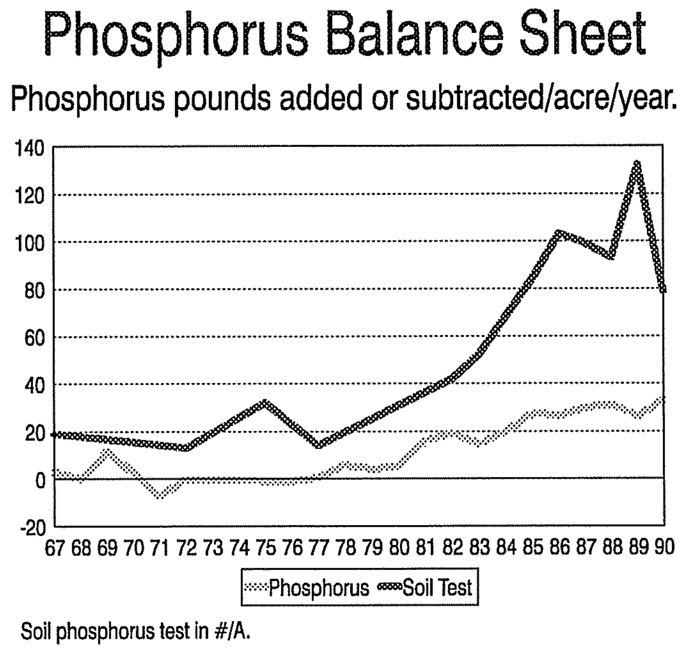


Figure 2-15

Phosphorus Stratification

The National Soil Tilth Lab. took soil samples from field #3 in 1994 before moldboard plowing. This field had not been plowed for 26 years. They sampled in two inch increments and the results are shown in **Figure 2-24.** They will sample this field in this same manner through 1998.

The phosphorus was very stratified with 104 ppm in the top two inches and 17 ppm in the 6 to 8 inch soil depth. There was a significant difference in the amount of phosphorus at each two inch level.

Potassium - The Problem Child

In 1989, special emphasis was given to monitoring soil potassium availability. Soil tests showed an increase in soil potassium levels from 82 ppm in 1967 to 200 ppm in 1989 **(Figure 2-16 & Table 2-4)**. While an increase in soil potassium levels have been found, analyses indicated no increase in corn ear leaf tissue potassium until the plowing in 1994 **(Figure 2-17 & Table 2-5)**. Ear leaf sampling done in 1984 indicated 1.38 percent leaf potassium. In 1985, levels decreased to 1.11 percent and the outer edge of the lower leaves were yellow and then turned brown. The corn did not stand well but

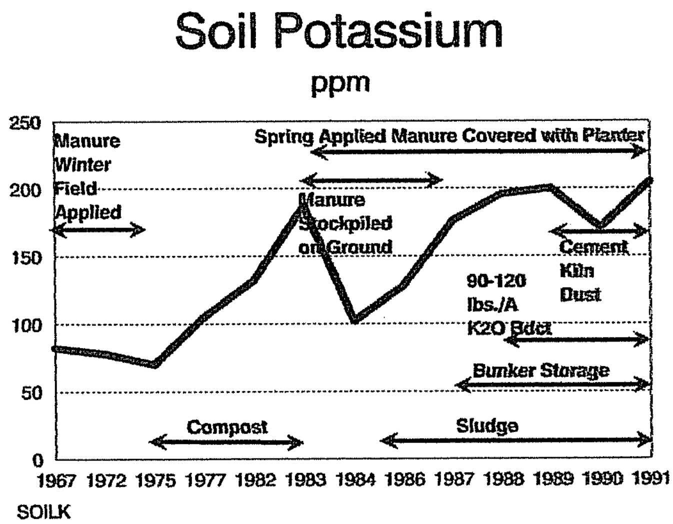


Figure 2-16

yielded 143 bushels per acre, 18 bushels above county average. The 1.16 percent potassium level in 1987 looked terrible at cultivation. The yield in corn was 118 bushels which was 25 bushels below the county average **(Table 5-1).**

Potassium is important during early plant growth, especially right after germination. When corn ear leaf magnesium levels are high, potassium is not being efficiently absorbed by the plant. The levels of ear leaf potassium are inversely related to leaf nitrogen and magnesium levels **(Figure 2-18 & Table 2-5)**. Potassium is absorbed by the plant most efficiently when magnesium is at a level of about 0.2 percent.

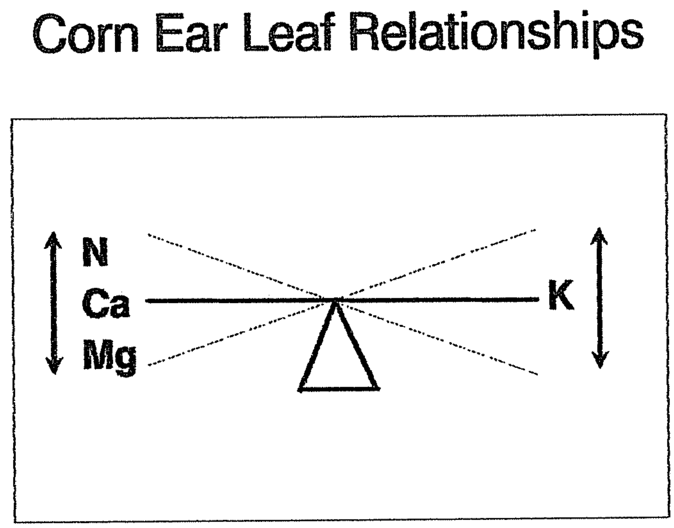


Figure 2-18

Experiments during 1986-1988 indicated a significant yield increase in both corn and soybeans when additional 30 and 60 lb/A rates of K_2O were added to 15 wet tons of manure/biosolids. Yield increases were sufficient to justify the additional potassium expense **(Figure 2-19 & Tables 2-8 & 2-9).**

Potassium sulfate was also included in this experiment and the economic data are shown in **Figure 2-20.** Basically, the corn and soybean yields were the same for both potassium chloride and potassium sulfate, but the potassium sulfate cost three times more. Earthworm counts were taken at the end of the experiment and were the same for both fertilizers.

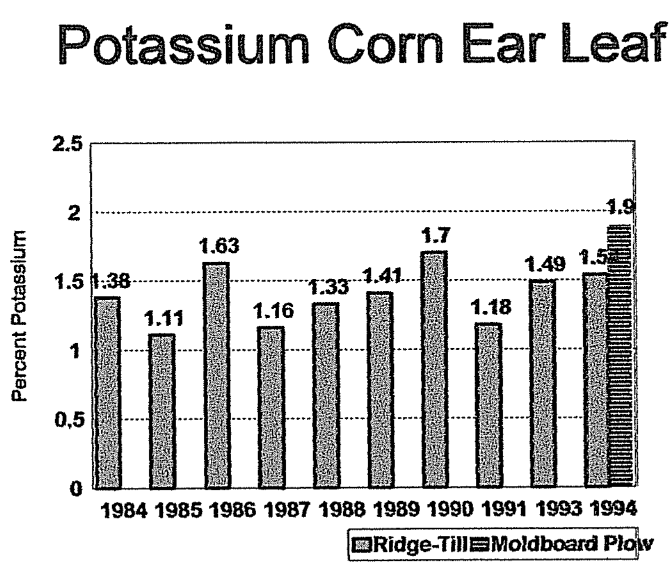


Figure 2-17

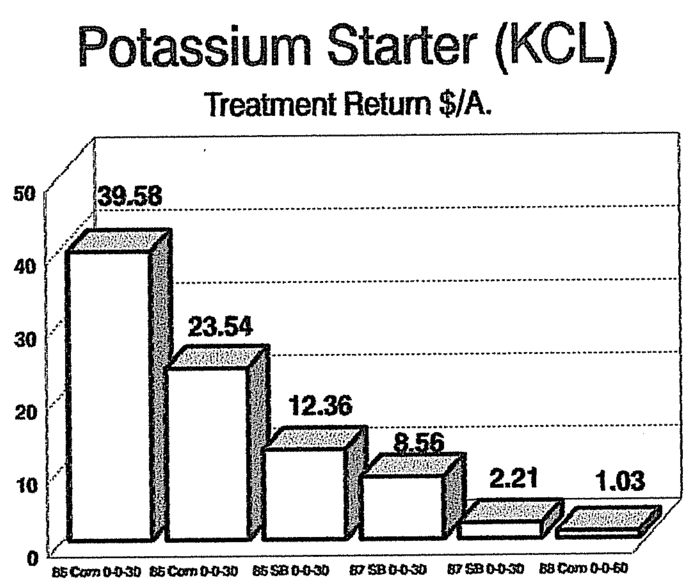


Figure 2-19

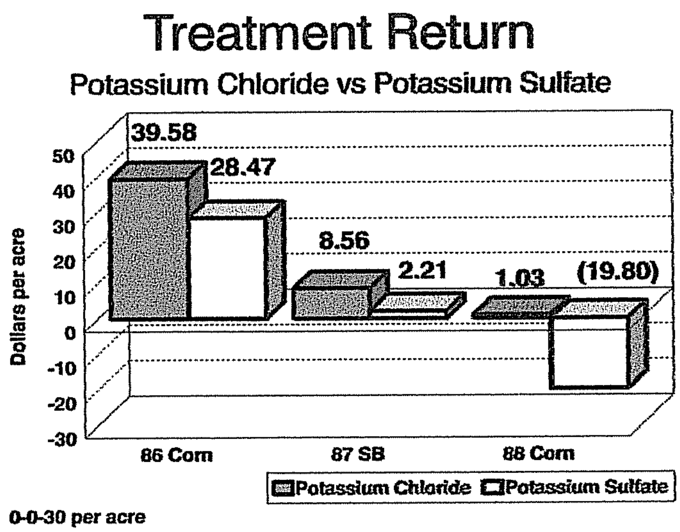


Figure 2-20

In 1989, banded K_2O rates were increased to 90 and 120 lb/A. Corn ear leaf potassium levels were significantly different at 1.32 percent and 1.46 percent, respectively. However, yields were similar at 141.2 and 140.8 bushels per acre, respectively **(Figure 2-21).** No economic benefit was obtained from the 120 pound per acre rate. All the above rates were placed 3 inches to the side of the row at seed depth. This placement is too shallow and nutrient uptake is restricted especially in dry years. In addition, both treatments displayed nitrogen deficiency during the growing season.

Broadcast potassium (0+0+120) was applied in four strips after oat harvest in 1992. These strips were compared to no purchased potassium. Three crops of hay were removed in 1993, the field was

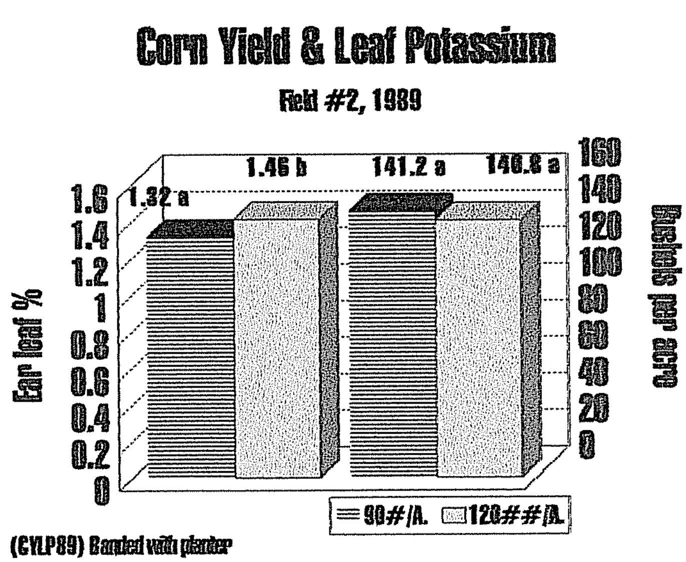


Figure 2-21

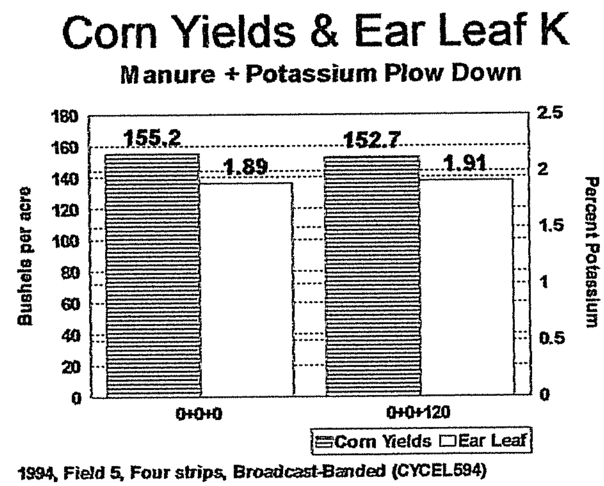


Figure 2-22

manured (8 dry tons per acre) and then plowed in the fall. The 1994 corn yields and corn ear leaf tissue tests are shown in **Figure 2-22.** The $21.63 additional expense for potassium did not increase the corn yield or increase the ear leaf potassium levels.

There were remarkable differences in corn ear leaf samples taken in 1994. Leaves ranged from 1.75 to 2.07 percent potassium taken from corn planted after moldboard plowing. Leaves ranged from 1.29 to 1.81 percent potassium taken from corn ground that **had not been** moldboard plow for the last 26 years **(Figure 2-23).**

In 2001, 169 pounds of KCL was broadcast in strips on top of spread manure. The idea was to keep the potassium away from the clay in the soil that

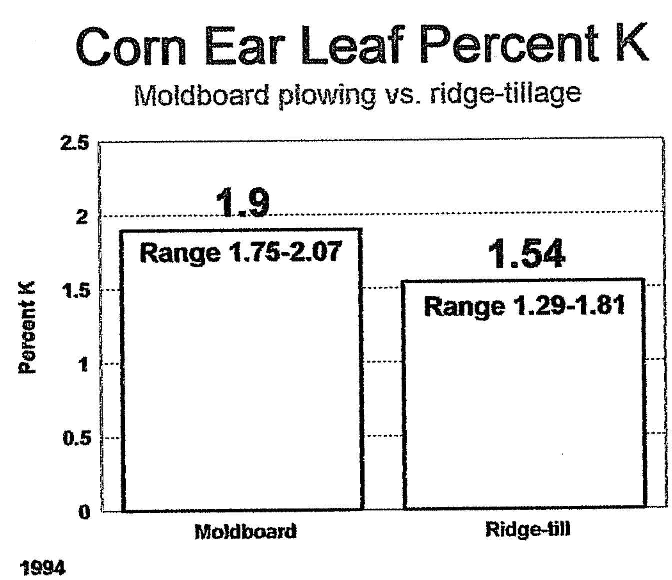


Figure 2-23

Soil Phosphorus

Bray P Test, mg/kg or ppm

Soil Depth	Hay 1994	Corn 1995	SB 1996	Corn 1997	Oats 1998
0-2 inches	104	68	93	134	122
2-4 inches	77	67	88	108	88
4-6 inches	29	66	76	99	62
6-8 inches	17	54	66	87	49
Mean - year	57	64	81	107	80

NSTL, Field #3, p5yr#3 **Moldboard Plow**

Figure 2-24

In 2001, 169 pounds of KCL was broadcast in strips on top of spread manure. The idea was to keep the potassium away from the clay in the soil that fixes or ties up the potassium. The corn yields were 144.97 bu. per acre with KCL and 146.40 bu. without. The soil test results were 208 ppm with KCL and 159.5 without and potassium ear leaf results were 1.99% with KCL and 2.01% without. No significant differences were shown in any of this data. Soybean and corn yields will be tracked on these strips for the next two years.

Nutrient Stratification

The National Soil Tilth Lab. took soil samples from field #3 before and after moldboard plowing.

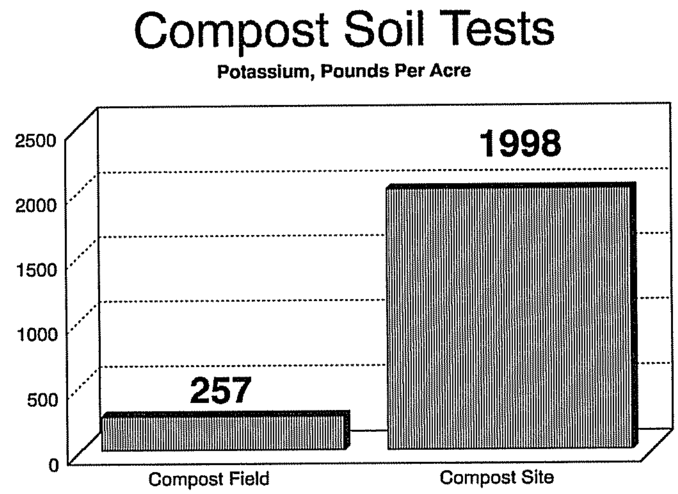


Figure 2-24b

This field had not been plowed for 26 years. They sampled in two inch increments and the phosphorus results is shown in **Figure 2-24 & Figure 2-24e.** The difference in phosphorus between the top two inches and the bottom two inches was 87 ppm before plowing. After plowing the difference was reduced to 14 ppm in 1995, less stratification. In 1996 the difference started back up to 27, 1997 increased again to 47 and another increase in 1998 to 73 ppm.

The potassium **(Figure 2-24a & Figure 2-24f)** was not as stratified as the phosphorus. The difference in potassium between the top two and the bottom two inches was 66 ppm before plowing. After plowing in 1995 the difference was reduced to

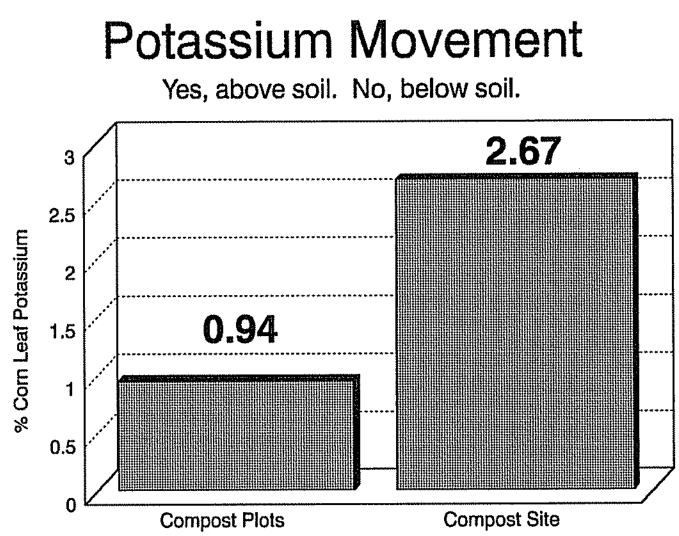
Soil Potassium, mg/kg or ppm

Exchangable K, Field #3

Soil Depth	Hay 1994	Corn 1995	SB 1996	Corn 1997	Oats 1998
0-2 inches	180	180	214	345	287
2-4 inches	122	156	163	238	141
4-6 inches	111	165	154	204	110
6-8 inches	114	158	160	192	103
Mean - year	132	165	173	245	160

NSTL, 5 year, K5YR#3 **Moldboard PLow**

Figure 2-24a



Corn needs 1.75% leaf potassium

Figure 2-24c

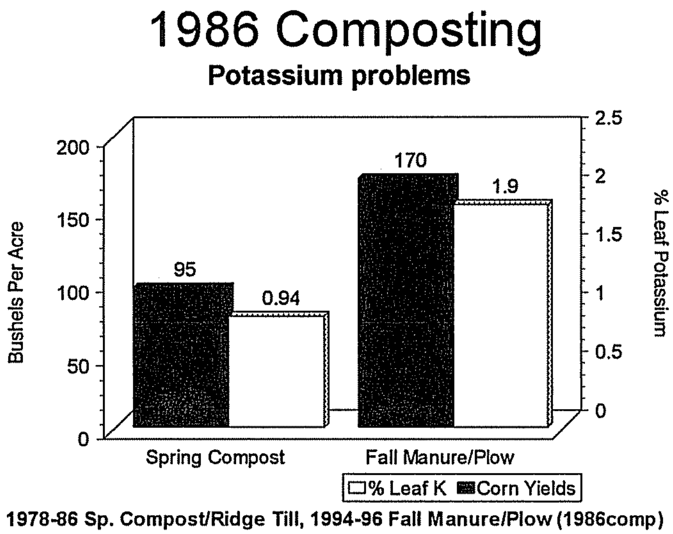


Figure 2-24d

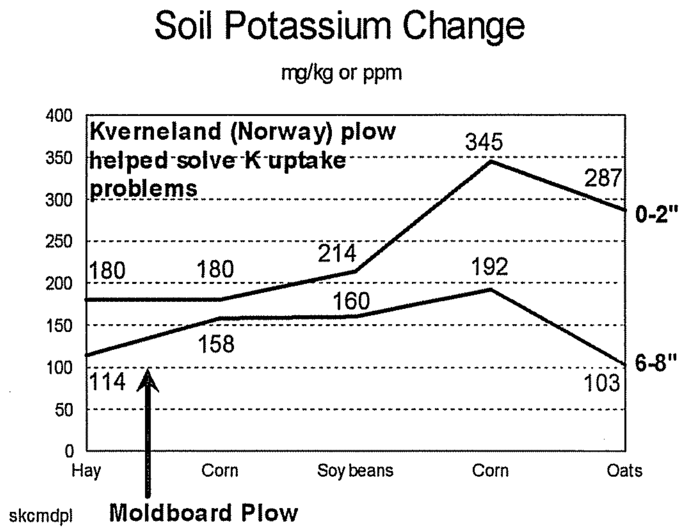


Figure 2-24f

22 ppm, less stratification. In 1996 the difference started back up to 54, 1997 increased again to 153 and another increase in 1998 to 184 ppm. The top two inches was significantly higher than the deeper soil levels before plowing. **Probing the top eight inches in one soil sample does not tell the whole fertility story, the average of the eight inch soil sample may seem adequate but most of the potassium could be in the top dry two inches of soil.**

Thanks to Doug Karlen and Keith Kohler and the other helpers for making this data available.

Composting (1975-1983)

The primary manure management objectives include handling techniques that maximize crop nutrient benefits and reduce the risk of polluting groundwater.

Before 1983, all of the cattle and hog manure was composted in an effort to reduce weed populations, a common problem on farms using manure as a fertility source. Although composting was effective in killing weed seed, it was time consuming. Furthermore, nitrogen leaching became a problem if composting was not completed on schedule. Potassium leaching from the pile was also a problem when using wet materials, despite proper handling **(Figure 2-24b).** The soil test taken from the compost site was 1998 pounds of potassium per acre, while the compost field plots tested 257. The corn leaf potassium was very low 0.94% in the compost plots, while corn grown on the old compost site had 2.67% potassium **(Table 2-24c).** Corn ear leaf potassium needs to be 1.75% for good plant growth. The 1986 spring compost on top of ridges

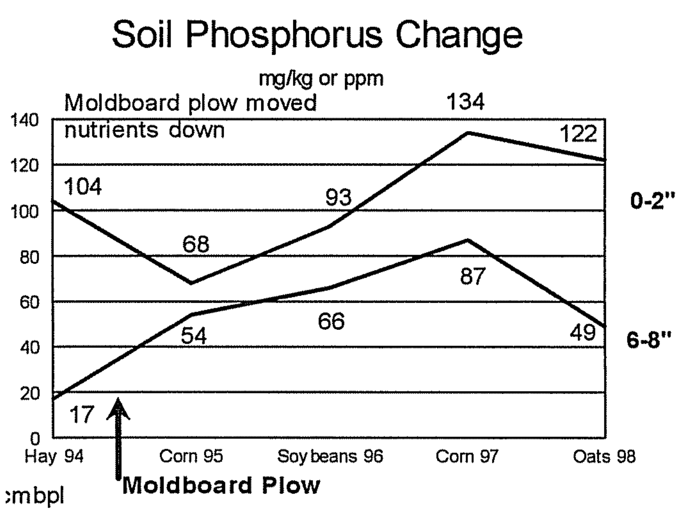


Figure 2-24e

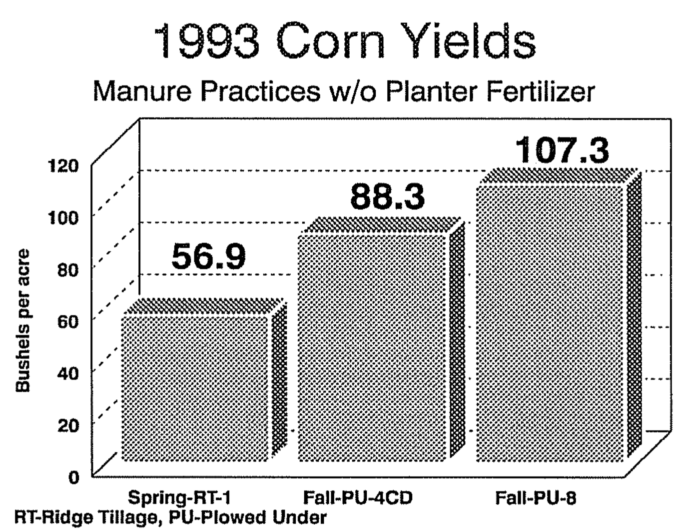


Figure 2-25

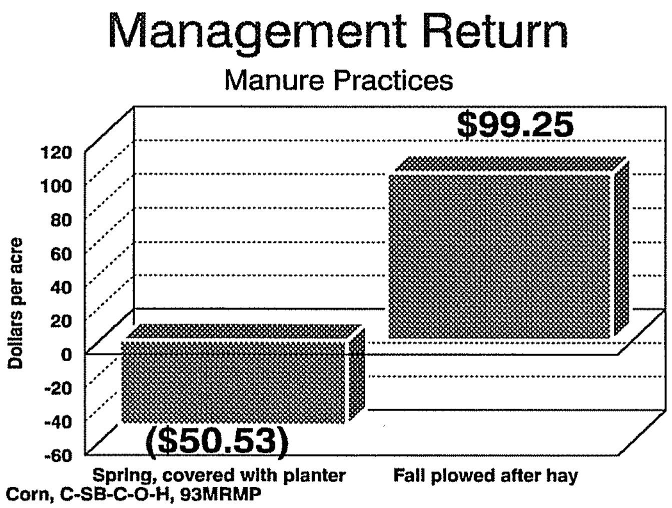


Figure 2-26

produced 95 bushel corn. In 1994-1996 period, when manure was applied in the fall following the hay crop and turned under with a moldboard plow, corn yields were 170 bushels per acre and corn ear leaf potassium was 1.9 per cent **(Table 2-24d).** The leachate from the compost tested 18-2-33 pounds of NPK per 1000 gallons which is saying potassium and nitrogen move with water above ground. Potassium is attached to the soil organic matter and clay and moves very little in the soil. Compost is very stable and releases nitrogren very slowly, probably not fast enough for a corn crop. Compost application one day before planting and on the soil surface were not in the best interest of the corn plant.

After much trial and error, composting was abandoned as ridge-till weed management without herbicides developed. Nevertheless, it was neces-

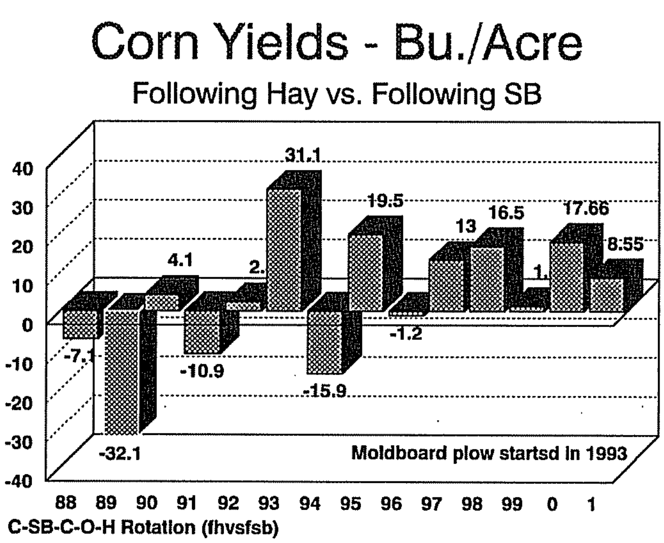


Figure 2-27

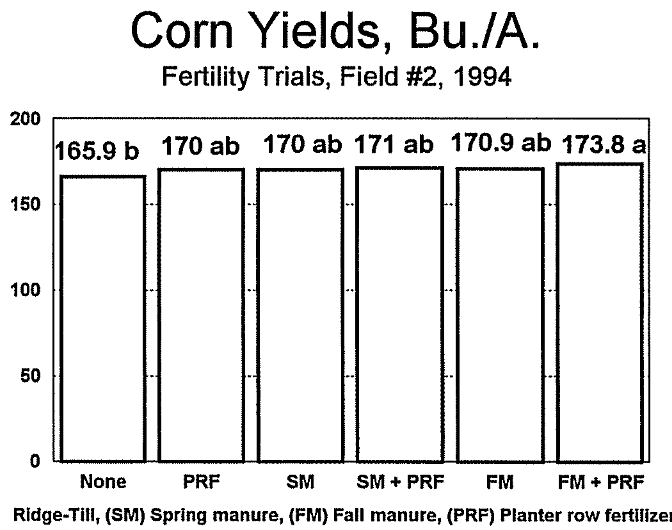


Figure 2-28

sary to find a way to handle stockpiled manure to decrease nutrient leaching.

Manure Management

The manuring practice from 1984 through 1992 was applying 2 dry tons per acre of manure/bio-solids before planting in spring. This material, along with the cover crop and top layer of ridge soil, is then removed by the front planter sweeps and placed in the valley area. Seed is planted into the freshly scraped ridge during the same operation.

While this process has helped to control weeds and remove fall planted cover crops, it has caused problems with nutrient availability early in the season. Nitrogen in the manure/bio-solids and cover crop is tied up and unavailable to plants until

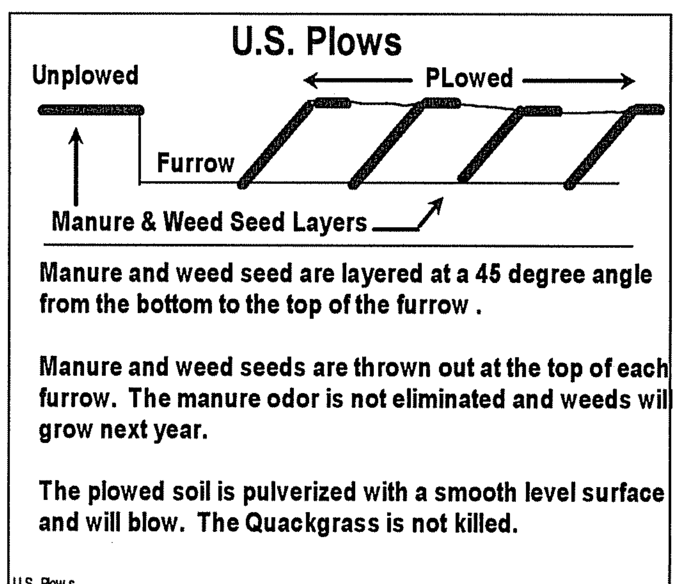


Figure 2-28a

composition is complete. Phosphorus and potassium are not immediately available because they have been pushed into the valley away from the seed.

In 1987, a large concrete holding tank, or bunker, was built to store manure and biosolids prior to spreading. The bunker helps reduce nutrient losses by keeping all the liquids. Both leaf and soil samples now test higher for nitrogen and potassium.

The corn crop in the dry May and June of 1992 showed potassium deficiencies even though the field had spring manure applied that contained 100 pounds K_2O in 90, 91 and 92 (Field #3). The manure was spread over ridges and covered with the planter and later cultivated twice. The corn roots did not find this fertility.

The 1994 experiments tested the practices of fall and spring manuring broadcast over ridges versus no manure for control. Statistically there were no yield differences between these practices **(Figure 2-28).** Adding planter row fertilizer did not change the yield either.

Nitrogen Loading

The amount of nitrogen supplied for the five year rotation through the manure/biosolids materials is explained in **Table 2-7.** The materials are spread at about 8 dry tons per acre following hay and plowed under in the fall. The second application of 4 dry tons per acre is spring applied ahead of corn planting **(Figure 2-36).** The amount of nitrogen available from the soil is about 1100 pounds per acre during the five year period. The amount

Moldboard Plow

Moldboard plow fields after sod

Change to sod moldboard with extensions to turn soil 180 degrees (weed seed & manure buried 6 inches).

Trash covers are used to throw weed seeds & manure to the bottom of the furrow.

Hydraulic driven gandy boxes may be used to apply the grain rye seed as you plow.

A harrow bar attached to the plow will cover the rye seed.

mdplow1

Figure 28b

removed by the crops during this same time is approximately 1544 pounds **(Table 2-2).**

BioSolids Stabilization

In 1989, cement kiln dust was added to municipal waste water. Iowa law requires that undigested biosolids be treated with an alkali material prior to land application. Treating with an alkali material like cement kiln dust raises the biosolids Ph for two hours which reduces pathogen numbers. Cement kiln dust contains some potassium and is lower in magnesium than the previously used dehydrated lime. In 1997, the Boone waste water plant changed to an aerobic digestion process. This process will reduce odor and pathogens substantially. The total nitrogen increased to 7.1% in 1997. The biosolids have been tested for nitrogen, phosphorus and potassium since 1987 and these numbers are found on **Table 2-3.**

Loading from Heavy Metals

The question about heavy metals in biosolids is asked many times. The biosolids are tested four times a year and records have been kept since 1984. **Table 2-6** explains maximum loading per acre for each element, the amount applied each year and the cumulative amount to date. The chromium levels were high during the 1980s. Since that time the wool tannery in Boone, which was the source of the chromium, has been pretreating its waste water before it enters the sanitary sewer.

Moldboard Plowing

Starting the fall of 1992, the hay field had manure applied in September and plowed under. The reasons for fall application were several, the bunker was full and spreading all the manure in the spring was a tremendous work load. The reasons for plowing were to save the nitrogen, move the phosphorus and potassium lower in the soil profile, and eliminate the odor **(Figure 2-28a & 2-28b).** The 1993 corn was planted on the flat surface of these fields with the Buffalo planter, the split depth bands were lowered as far as possible and the residue guards raised to the level position. The new practice of split depth bands gives much better floatation of the row units on the soft tilled soil. The Buffalo ridge-till planter does an excellent job of planting on soft tilled fields. There is no reason to have another kind of planter to plant flat tilled fields. The sweep is left on the planter to level the soil and remove weeds. At second cultivation weeds in the row were covered and ridges formed for the next two years of row crops.

The fall manure/plowed fields grew faster than spring applied manure ridged field. The plowing will occur only once during the 5 and 7 year rotations. Research done by Gyles Randall at Minnesota shows that plowing moves the stationary nutrients like phosphorus and potassium lower in the soil profile.

The two 1993 corn fields that were fall manured and plowed were considerably higher in yields than the field where manure was spring applied over ridges and then ridge-till planted **(Figure 25).**

The 1993 management return was about $150.00 more for the fall applied manure plowed under compared to the spring applied manure over the top of soybean ridges **(Figure 2-26).** The spring applied manure needed planter fertilizer and side-dress nitrogen while the fall applied system did not respond to either application of purchased fertilizer.

All manure was spring applied to the corn following hay for the years 1988 through 1992. **Figure 2-27** shows corn yields following hay were less than corn following soybeans three out of the five years. In 1993 when the manure was fall applied and plowed under (without additional purchased fertilizer), the corn following hay was 31 bushels per acre more than the corn following soybeans (without purchased fertilizer). 1994 was an excellent growing year with good release of nutrients. The ridge-till corn was 15.9 bushels better than the plow corn. The plow corn was very tall and dense, the damp August and September caused a blight which caused the corn to die early. **(Figure 2-27).** The ridge-till corn was shorter, the wind could get through this field and keep it drier. We will be able to follow the fall/plow vs. spring/planter manure applications for several years.

Three different plows were used during the fall of 1993 to turn under manure and hay stubble. The three plows used were; a two-way swing plow, roll over two -way plow, and a standard one-way plow. None of the plows did an acceptable job of turning over the sod and turning under the manure. All of the plows set the soil up on edge, leaving manure on top, leaving bunches of orchardgrass to regrow and leaving weed seeds near the surface to grow next year. The two-way swing plow pulled very hard. It was hard to maintain a uniform plow depth because it did not have a trailing wheel. The roll over two-way plow does not have enough clearance for residue. The standard John Deere one-way plow set the soil up on edge and the field had to be plowed in lands. The moldboards were changed in 1993 on the one-way plow to try to turn the soil over completely; covering manure, grass, and weed seeds.

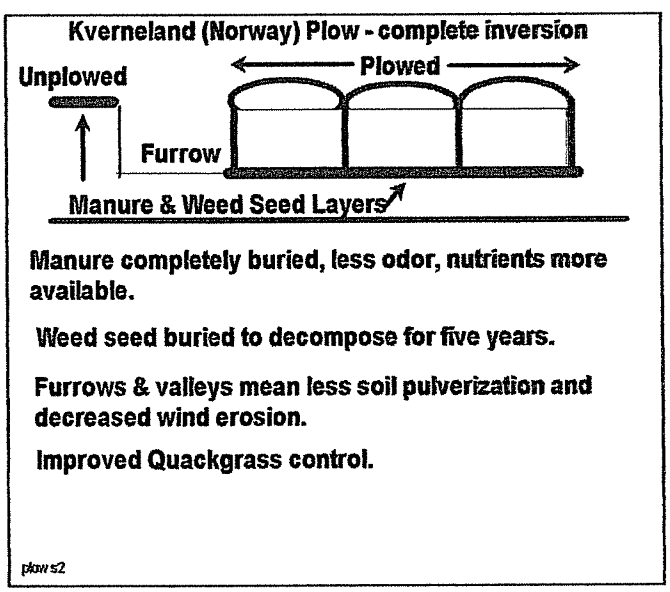


Figure 2-29

A Kverneland (Norway) plow with longer moldboards was purchased in 1997 (Figure 2-29). This plow is a very important item in three areas of our farming system. Placing weed seeds at the bottom of the furrow helps with weed management. Placing the manures lower in the soil profile helps reduce stratification of nutrients (Figure 2-24 & 24e for phosphorus and potasium (Figure 24a & 24f). Last but not least is odor control when spreading solid manures on the hay field. This variable width and pull up bottoms makes it possible to plow under the slick manures immediately after spreading. A mechanical front wheel tractor with traction lock rear wheels makes this all possible.

Corn Yields, Bu./A.

Treatment	1993 (flood)	1994	1995	1995 - Field #4C	1996
FM/MP	#4D-88 a	#5-155 a (1)	#3-179		#1-170
FM/MP + PRF	#4D-91 a				
FM/MP + K		#5-153 a (1)			
SM/RT	#1-57a *	#2-170a *	#4D-158 ab	162 b	#5W-170a
95 SM/RT					#5W-169a
FDB/RT			#4D-160 a		
SM/RT + PRF	#1-75b *	#2-171a *	#4D-157 ab	168 a	#5W-175a
Nothing/RT			#4D-154 b	155 c	
PRF				158 bc	
Nothing for 2 yrs.					#5W-158b
SM/RT for 2 yrs.					#5E-172

FM/MP-Fall manure/moldboard plow, PRF-Planter row fert.,SM/RT-Spring manure/ridge till, FDB-Fall deep band, *-Did not follow FM/MP, (1)-Leaf blight

Figure 2-30

Manure Experiments

Applying spring manure at 8 dry tons per acre on ridge till corn (year three in the rotation) in 1995 increased yields from 155 to 162 bushels in field #4C (**Figure 2-30**). The oats in these strips went down in 1966. A 8 ton spring application on field #5W in 1996 increased the corn yield from 158 to 170 bushels per acre. These two experiments show a need for manuring (corn) the third year of the rotation. Field #4D was spring manured at 8 tons for soybeans in 1994 and did not respond to manuring in 1995. The 154 bushels per acre is no different than 158 where the manure was applied (**Figure 2-30).**

Applying spring manure at 8 dry tons per acre on ridge till soybeans did not improve yields in 1994 or 1995 (**Figure 2-31).** Planter row fertilizer was not consistent in increasing yields and if a yield increased (Field #5-1995) it did not pay for the fertilizer. The $13.25 per acre revenue increase from the additional soybean yield did not pay the $22.75 per acre fertilizer bill and produced a loss of $9.50 per acre (**Table 2-9, Col. L).** We no longer apply manure or purchased fertilizer during the year of soybean production. The 8 dry tons per acre fall applied following hay and moldboard plowed takes care of the fertility needs of the corn in the first year of the rotation and also the soybeans in the second year of the rotation. The history of manure applications and rates are found in **Table 2-10.** Yield trials are telling us more than the soil and leaf tissue tests.

Soybean Yields, Bu./A.

Ridge Till, no herbicides

Treatment	1994	1995 - Field #5
Nothing	#4C - 70 a	59 b
Planter row fertilizer (PRF)	#4C - 69 a	62 a
Spring manure	#4C - 70 a	58 b
Spring manure + PRF	#4C - 69 a	58 b
Spring manure	#4D - 73	

Fall manure/moldboard plow 2 years prior

Figure 2-31

Manure Bunker

A concrete hillside manure bunker was built in 1986 and is located 80 rods from all farm steads (**Figure 2-32).** A drive down ramp was added in 1999 so that the tractor loader could pick up liquids and solids together. Our spreaders are not tight enough to haul just liquids out on the road.

Manure from hogs and cattle lots has been hauled in dump wagons to the manure bunker since

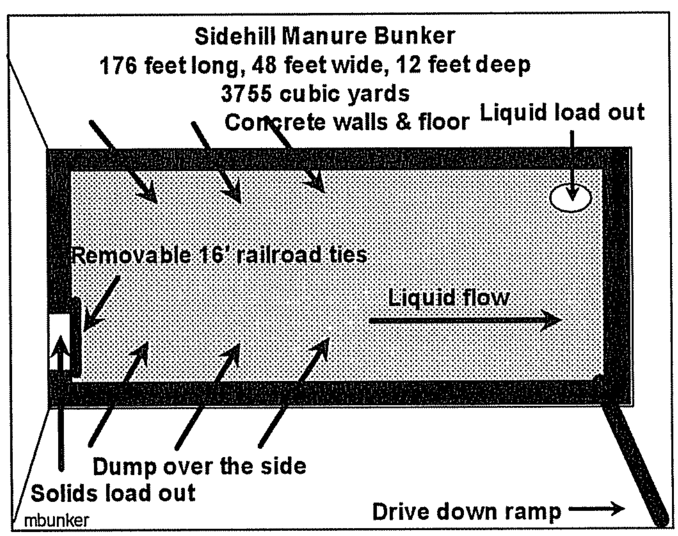


Figure 2-32

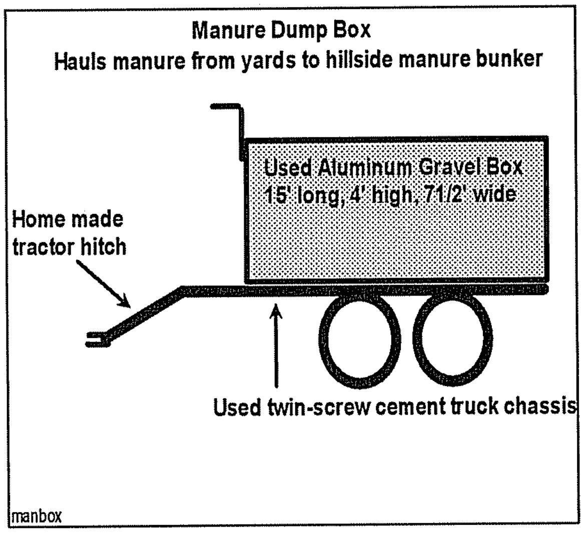


Figure 2-33

1986. The front wheels of the wagon sometimes came off the ground when the load slid out the back. One time the hoist went through the floor of the wagon box. The back door sometimes came open on the way to the bunker. Two spindles have broken on the wagons. The wagons were difficult to back up to the bunker for unloading. It was time for this era to come to an end.

A 15 foot used aluminum gravel truck box was mounted on a old twin screw cement truck chassis **(Figure2-33).** A front hitch was made to attach to the tractor drawbar. Additional oil was added to the tractor hydraulic system to handle the four in one cylinder truck hoist. The floor was covered with 2 by 8 inch tongue and grove treated planks. The material costs were about $4000.00. The larger dump box is much easier to back and the endgate does break open. The new dump box has been used to haul dirt. Biosolids from the city of Boone is also dumped into this bunker.

During 1999 a drive down ramp was made in the southwest corner of the manure bunker **(Figure 2-32).** The reason for the ramp was to allow tractor loader to go down into the bunker and pick up both liquids and solids. The Gehl spreaders are not leak proof and need some solids to go with liquids in the south end of the bunker. The liquid level should be lowered to the four foot level before we open the north load out.

Gravel field lanes to the bunker allow every day access year round even when it's raining. Prior to building the bunker, manure in hog pens and cattle became a real mess during spring thaw because of muddy fields. The bunker has allowed us to clean when the pens and yards start to thaw out during the spring. In the summer when it rains and it's to muddy to work in the field, we clean hog pens and cattle yards. This makes good use of labor.

Manure Summary

Figure 2-34 is a summary of manure applications, some randomizied and replicated shown by small letters after the yields. The others have been strips left without manure to compare with manure applications on either side. The results show no increase in yields of corn or soybeans in the year when manure was applied on top of ridges spring or fall. We have to spread manure someplace in the spring and the only place is on top of ridges. The no increase yield does make sense when you consider the fact that the manure is applied on the surface right ahead of planting and pushed away from the row by the planter. We thought there would be some response but that has not been true. We think the corn planted in the 3rd year of the rotation needs some added fertility. In 2003 we will spring surface apply some manure on a strip (B) in a field going to soybeans **(Figure 2-35).** We will measure soybean yields from the spring manure strip (B) and compare to strips (A&C) on either side without manure. In 2004 this field will be planted to corn, strip (A) will receive spring applied manure and strips (B&C) will

Manure applied on top of ridges

No yield increase during the year of application

	Manure	No manure
C-94-#2-fall	170.9 ab	165.9 b
C-94-#2-spring	170.0 ab	165.9 b
SB-94-#4-spring	70 a	70 a
SB-95-#5-spring	58 b	59 b
C-01-#5-spring	132	129.2
C-02-#3-spring	170.7	170.7
SB-03-#1-spring	33.07	33.35

(manridg)

Figure 2-34

Spring manure SB

Increase corn yields the next year?

Year	Crop	Strip (A)	Strip (B)	Strip (C)
2003	SB	No Manure	4 dry tons, 33.07	No manure, 33.35
2004	Corn	4 dry tons, 208.16	No manure, 195.64	No manure, 200.23
2005	Oats	Lodging Score	Lodging Score	Lodging Score

All strips 16 dry tons plowed under fall 2001(smsb#1-03)

Figure 2-35

be the controls. This experiment should tell us three things. Will spring manure applications on soybeans and corn continue to show no yield responses? Will the manure application in strip (B) 2003 give a yield response the next year when planted to corn? Do we need to apply spring manure either year? How will the 2004 corn yields of strip (C), without any manure, compare to strips (A) or (B)? The 2004 results did not show a yield increase in strip (B) that had spring manure the previous year **(Figure 8-35)**. The spring manured 2004 strip (A) had the highest corn yield. The manure was taken directly from the bull barn (straw bedding) instead of manure bunker (manure & biosolids). Since this was a one pair comparison and yields were simular, no conclusions can be made. This field will be planted to oats in 2005. Will the 2003 manure application for soybeans, (two years prior) to oat planting reduce the lodging problems in strip (B)? This field was manured with 16 dry tons per acre and plowed under in the fall of 2001.

Manure Odor Control

Manure containing bedding can't be injected into the soil, so how do we control odor with surface spreading of manure? Spreading manure in late fall over the entire field and hoping the ground does not freeze before the field can be plowed is not a good program. We got caught in the fall of 2000 and the field was not plowed until the spring of 2001 and the odor was there all winter long along with the nitrogen losses into the air.

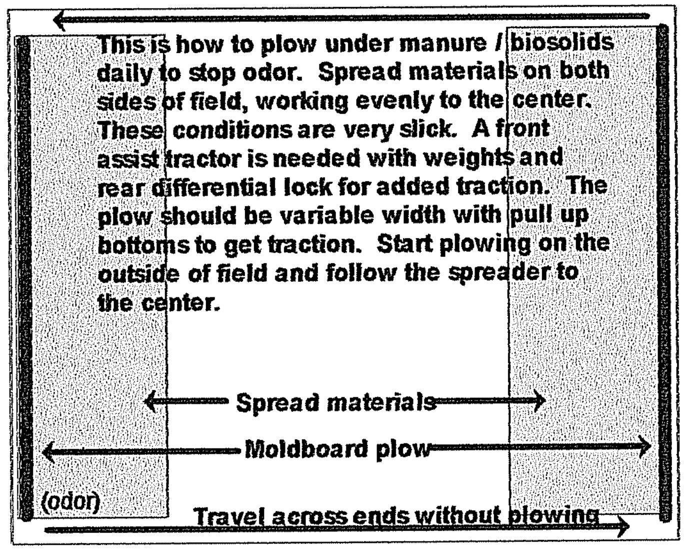


Figure 2-36

Spreading a strip along one side of the field and then plowing that land will leave many back and dead furrows in the field. Buying a $50,000 semi mounted rollover (two way) Kverneland plow is not the answer.

One day while spreading manure the light went on how to control the odor and not spend any money. Spread manure on both sides of the field, working evenly to the center **(Figure 2-36).** Plowing can start as soon as there is some distance from the side discharge spreader and then follow the spreader to the center of the field. A front assist tractor with weights and a rear differential lock is needed for added traction so you can pull the plow on this slick surface. The plow should be variable width with pull up bottoms. If the ground is dry and hard and the surface slick and you can't pull 5 bottoms, lift up and hang the last bottom and plow with 4. These are the reasons for the Norway (Kverneland) plow that has all the above items plus complete inversion sod bottoms with trash covers. The odor is gone with the plowing.

Fall Manure Plowdown

Prior to 1993 the fields had not been moldboard plowed for 25 years. The hay fields had been chiseled or worked with an off set disk. Doug Buhler and Keith Kohler from the National Soil Tilth Lab took soil samples for five years from field # 3. They found the phosphorous and potassium were higher in the top 2 inches compared to the 6 to 8 inch

Fall Manure Plowdown

Strip Comparsions, Bushels per acre

Year	Rot.yr.-Crop	Field #	Year Applied	Manure	None	Manure Advantage
2002	1-Corn	1	2001	175.46	161.05	15.41
2003	Sb	1	2001	33.07	32.67	2.4
2004	3-Corn	1	2001	197.98	154.45	43.53
2003	1-Corn	2	2002	213.52	190.44	23.08
2004	SB	2	2002	64.27	62.66	1.61
2005	3-Corn-P33P67	2	2002	223.53	153.21	70.32
2005	3-Corn-P31665	2	2002	206.89	113.7	93.17
2004	1-Corn	5	2003	214	207.8	6.2
2005	SB	5	2003	72.64	67.19	5.45
2006	3-Corn	5	2003	190.1	178.43	11.67
2005	1-Corn	3	2004	230.93	227.4	3.53
2006	SB	3	2004	60.23	57.93	2.3
2207	3-Corn	3	2004	228.17	214.05	14.12
2207	1-Corn	1	2006	200.74	179.89	20.85

16 Dry Tons per Acre

Figure 2-36a

samples before plowing. After plowing the fertility test numbers were closer together at the different soil depths **(Figures 2-24e &2-24f).** In dry years the roots go down for moisture and do not use the fertility close to the surface.

Our economic advantage has improved since using the moldboard plow **(Figure 7-2).** The moldboard is used only following hay, covering the fall spread manure, reducing the odor and placing the fertility and weed seeds at lower depths. **This has been a very good change.**

Strip comparisons are showing yield advantages from the fall manure plowdown **(Figure 2-36a).**

Purchased Fertilizer

All of the experiments in this section have had manures applied at least twice during the C-SB-C-O-H rotation.

Corn

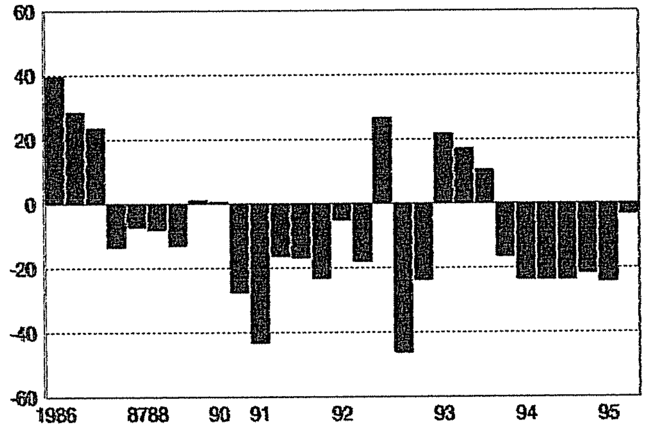
Table 2-8 & Figure 2-37 shows the 33 corn purchased fertility experiments starting 1986. All five side-dress nitrogen trials in the late 1980s did not increase corn yields therefore reducing net profit by $10.11 per acre.

In the planter applied liquid trials, six out of the fifteen increased the corn yield. There were four trials with positive dollar returns and eleven negative returns. The average return of the planter liquid experiments was a negative $12.73 per acre.

Applying dry potassium with the planter in the late 1980s gave a positive return of $16.92 per acre.

Purchased Fertilizer Return, $/A

Corn



Manure/bio-solids are the basis of the fertility program.

Figure 2-37

Four out of the five trials increased the corn yield and improved the bottom line.

Only two out of the six planter NPK trials increased the corn yield. Only one trial produced a positive return. The average economic return was negative at $12.31 per acre.

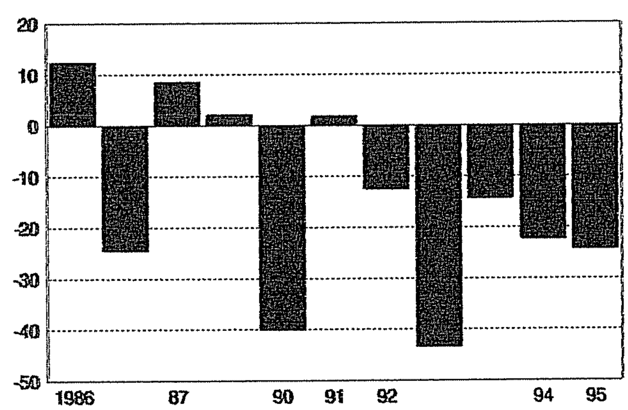
Soybeans

Table 2-9 & Figure 2-38 shows the eleven experiments with purchased fertilizers for soybeans.

The four dry potassium trials all increased the soybean yield and all had a positive return. The average return was positive at $6.23 per acre. The

Purchased Fertilizer Return, $/A.

Soybeans



Manure/bio-solids are the basis of the fertility program.

Figure 2-38

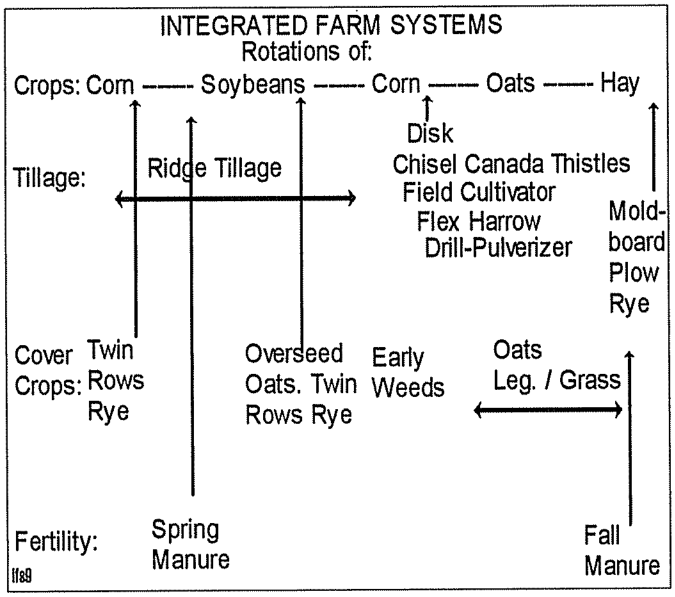


Figure 2-39

dry NPK did not increase the yield and lost $12.43 per acre.

In the planter liquid trials, two times the fertilizer was placed just under the seed and the yield was reduced **(Table 2-9, Col. G&H).** There was one positive yield responses **(Table 2-9, Col. L).** The average economic return was a negative $25.67 per acre.

Again, remember all these trials were conducted in a manure fertility system.

Liquid Fertilizer Shoe

A liquid fertilizer shoe was developed with the help of Doug Alert, manufactured and sold by Buffalo. This planter runner shoe would place liquid fertilizer 2 inches below the corn seed. Fertilizer economics was the restriction for the amount of fertilizer that could be placed 2 inches below the corn seed. Tests were conducted on our farm during 1993-1995 and found in **Table 2-8, Line 20.**

Systems

Figure 2-39 tells many stories about diversity in crops, tillage, and fertilization. The crop rotation is what my father used during his farming career. The rotation of tillage practices is used for several reasons. The plow is used to cover manure and destroy the sod crop and move the potassium and phosphorous lower in the soil profile. Ridge tillage is used during the row crop part of the rotation which reduces erosion, lessens weed pressure, and reduces fuel and labor costs. Manure is applied in the spring for the corn crop following soybeans. Ground cover is 100% for the two years during the oats and hay part of the rotation. Ground cover during the three years of row crops is as follows; rye broadcast while fall plowing the hay field, twin rows rye drilled on ridges after corn harvest and oats broadcast with hi-boy over soybeans during mid August.

Summary

Ridge tillage combined with fall rye cover crops and spring manure application restrict early nitrogen and potassium uptake into corn plants.

Liquid fertilizers prices at $3.00 per gallon or more have not been good investment on the Thompson farm.

Solid livestock manures with bedding and cattle droppings on pasture should be plowed under in the fall. The fall manure/plow has eliminated the visual potassium deficiency. Liquid manure should be injected.

Row fertilizer should be placed 6-8 inches deep in the center of the ridge in the fall.

Planter row fertilizer should be placed 2 inches below the seed.

Planter row fertilizer is not needed for corn following hay with the fall manure/plow practice.

It appears that four dry tons of manure for the soybean crop, second year in rotation, is about right for the corn and the following oat crop.

PLOADING.XLS

	A	B	C	D	E	F	G
1		Phosphorus Loading					
2							
3						#P added	P1 Soil
4	Year	# P added	#P lost	Difference	Farm	or lost	Test
5		to farm	from farm		acres	per acre	rpm
6							
7	1967	5279	4562	717	260	2.76	9
8	1968	3300	3329	-29	260	-0.11	
9	1969	7632	4395	3237	260	12.45	
10	1970	4615	3958	657	260	2.53	
11	1971	530	2397	-1867	260	-7.18	
12	1972	1975	2019	-44	260	-0.17	6
13	1973	2238	2345	-107	260	-0.41	
14	1974	2165	2384	-219	260	-0.84	
15	1975	1453	1779	-326	260	-1.25	16
16	1976	1457	1797	-340	260	-1.31	
17	1977	1536	1428	108	260	0.42	7
18	1978	3977	2467	1510	260	5.81	
19	1979	3766	2791	975	260	3.75	
20	1980	5419	3989	1430	260	5.50	
21	1981	7547	3379	4168	260	16.03	
22	1982	9210	4220	4990	260	19.19	21
23	1983	7294	3475	3819	260	14.69	47
24	1984	8741	3637	5104	260	19.63	
25	1985	12082	5038	7044	260	27.09	42
26	1986	11941	5083	6858	260	26.38	52
27	1987	11264	3577	7687	260	29.57	50
28	1988	11315	3162	8153	260	31.36	47
29	1989	9359	2728	6631	260	25.50	66
30	1990	11892	3329	8563	260	32.93	40
31							
32	Total pounds phosphorus per acre added during 24 yrs.					264.30	
33							
34	Average	6082.79	3219.50	2863.29	260.00	11.01	
35							
36	Average pounds phosphorus added per acre per year					11.01	
37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							

Table 2-1

NPKREMOV.XLS

	A	B	C	D
1	Nutrient Uptake, pounds per acre			
2				
3	Entire Crop	Nitrogen	P2O5	K2O
4				
5				
6	Rye broadcast	40		
7	Corn - 150 bu. X 1.5	225	91	196
8	Rye drilled - 2 rows	40		
9	Corn total	305		
10				
11				
12	Soybeans - 55 bu. X 5.4	299	68	175
13	Oats broadcast	40		
14	Soybean total	339		
15				
16				
17	Corn - 150 bu. X 1.5	225	91	196
18				
19				
20	Oats - 85 bu. X .115	98	39	117
21	Stubble - .9 ton X 53	47	17	50
22	Oat total	145		
23				
24	Hay - 10 ton X 53	530	85	250
25				
26				
27	Total	1544	391	984
28				
29				
30				
31				
32				
33				

Table 2-2

NPKMASL.XLS

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	NPK Contained in Bunker Manure/Biosolids (aerobic digestion of biosolids starts in 1997)																		
2	Per cent of Dry Matter																		
3																			
4	Year	-----------pH-------			Phosphorus			Potassium			Total Kjeldahl Nitrogen			Nitrate Nitrogen			Ammonia Nitrogen		
5		Farm	City	Mix	Farm	City	Mix	Farm	City	Mix	Farm	City	Mix	Farm	City	Mix	Farm	City	Mix
6	1987	8.6	7.5		0.62	1.02		4.88	0.26		2.76	4.22							
7	1988	7.9	7.6	7.6	0.57	1.11	1.09	2.85	1.45	1.78	3.16	4.45	4.47						
8	1989				0.60	0.66	0.95	1.62	0.66	1.74	2.57	2.85	2.46						
9	1990				2.40	0.65	1.20	4.40	0.85	1.30	3.90	2.35	2.50	<0.10	<0.10	<0.10	2.00	1.05	1.20
10	1991				1.90	1.10	1.80	1.60	0.61	0.82	2.60	2.40	3.30				0.50	0.60	0.80
11	1992				0.60	1.00	1.00	1.30	1.30	1.20	1.70	1.00	1.10						
12	1993	8.2	7.8	7.5	1.70	0.90	0.80	0.58	1.20	0.96	1.80	2.90	2.40	<0.10	<0.10	<0.10	0.60	1.00	0.80
13	1994	7.1	7.8	6.9	0.80	0.80	0.60	1.60	0.67	0.72	6.90	3.50	5.30	<0.10	<0.10	<0.10	1.10	1.10	1.10
14	1995	8.4	8.2	8.1	0.90	0.90	0.70	2.00	0.63	1.80	2.50	2.70	2.60	<0.10	<0.10	<0.10	0.40	0.80	0.40
15	1996	6.3	11.6	10	1.35	1.25	1.25	0.93	1.90	1.70	1.90	2.55	2.35	<0.10	<0.10	<0.10	0.55	0.35	0.45
16	1997	8.6	6.8	8	0.87	2.90	1.80	1.13	0.37	0.93	2.43	7.10	4.28	<0.10	<0.10	<0.10	0.47	0.10	0.19
17	1998	8.2	7.3	8	1.40	2.50	1.10	1.90	0.24	0.56	1.80	4.40	1.40	<0.10	0.10	<0.10	0.70	0.10	0.20
18	1999	8.4	9.2	8.5	0.75	2.05	1.75	1.12	0.81	0.89	1.70	2.25	2.15	<0.10	<0.10	<0.10	0.40	0.70	0.75
19	2000				1.50	0.85	1.20	1.58	1.60	2.05	2.90	3.15	3.25	<0.10	<0.10	<0.10	0.85	0.90	1.00
20	2001	7.4	8.2	8.2	0.68	1.13	1.03	1.90	0.99	1.03	2.16	2.12	1.90	<0.10	<0.10	<0.10	0.62	0.53	0.63
21	2002	7.3	8.5	8.8	1.43	2.16	0.97	1.43	1.41	1.41	2.58	2.83	2.85	0.02	0.00	0.02	1.21	0.80	0.87
22	2003					0.85		1.40	0.40	1.20	3.00	2.30	3.00	<0.10	<0.10	<0.10	0.67	0.58	0.51
23	2003	7.5	8.6	8.1	1.90	1.50	1.30	0.87	0.54	0.82	2.10	3.50	2.00	<0.10	<0.10	<0.10			
24	2004	7.8	7.9	7.7	0.88	1.40	0.80	1.80	2.10	1.80	1.90	2.60	2.10	<0.10	<0.10	<0.10	0.79	0.87	0.78
25	2004				0.45	3.00	1.20	1.70	0.40	1.30	2.50	4.30	2.20	<0.10	<0.10	<0.10	1.30	1.20	1.10
26	2005	8			1.10		2.20	0.25		0.96	4.50		3.20	<0.1		<0.1	0.82	0.81	0.88
27	2005		7.7			1.50			0.17			1.70			<0.1		0.42	0.44	0.44
28	2006	8.1	8	8.2	0.50	1.60	1.30	1.70	1.60	1.40	1.40	2.80	2.80	<0.1	<0.1	<0.1	0.19	2.00	1.40
29	2007		8.1	7.8	0.55	1.60	0.69	2.40		1.50					<0.1	<0.1	0.42	1.10	0.59
30	2008		7.8			1.50			0.30			3.60							
31																			
32																			
33																			
34																			
35	Avg.	7.85	8.15	8.10	1.07	1.41	1.18	1.78	0.89	1.27	2.67	3.11	2.74	<0.10	<0.10	<0.10	0.74	0.79	0.74

Table 2-3

SOILTEST.XLS

	A	B	C	D	E	F	G	H	I	J	K	L	M
1						Summary of Soil Tests							
2						Manure System							
3													
4	Year	Lab.	Field	Organic	Phosphorus	Potassium	Magnesium	Calcium	pH	CEC	Percent	Percent	Percent
5			No.	Matter %	P1 ppm	ppm	ppm	ppm			Potassium	Magnesium	Calcium
6	1967	Tuloma	1	4.75	11.5	90			7.3				
7	1967	Tuloma	2	3.8	7.5	64			7.5				
8	1967	Tuloma	4--5	5	8.5	91			7				
9	1972	ISU	H		3	86			7.4				
10	1972	ISU	B		10	70			6.55				
11	1975	MVTL	S	5.3	8.5	75	475	6000	7.3	34.1	0.5	11.4	87.9
12	1975	MVTL	E	4.7	12.5	65	475	5750	7.4	32.8	0.5	11.9	87.5
13	1975	MVTL	W	4.3	27	75	500	5000	7.2	29.3	0.6	14	85.3
14	1977	MVTL	9	5.6	7.5	90	425	7250	7.2	39.9	0.5	8.7	90.6
15	1977	Eagle Grove	9	6.7	6	120	490	7680	8	43.2	0.6	9.4	88.8
16	1982	A&L	3	4.8	21	132	323	3840	8	22.2	1.55	12.1	86.35
17	1983	MVTL	1--9	4.08	47	187	654	5330	6.88	32.7	1.52	16.94	81.4
18	1984	A&L	1--9	4.04	42	102	321	2490	6.82	16.32	1.65	17.04	74.88
19	1986	A&L	1--9	4.72	52	128	396	2065	6.58	15.15	2.18	22.16	68.06
20	1987	A&L	1--9	4.9	50	176	427	2772	6.92	18.75	2.81	19.76	72.44
21	1988	A&L	1--5	6.82	47	196	466	3565	7.4	22.4	2.23	17.97	79.33
22	1989	A&L	1--9	4.5	66	200	483	3127	7.1	18.8	2.48	19.89	70.79
23	1990	A&L	1--9	4.53	40	171	391	2743	6.9	18.1	2.51	18.71	74.42
24	1991	Liquid Grow	2	4.78	52	213	385	3048	7.63	18.98	3.08	17.68	79.33
25	1991	Liquid Grow	3	4.48	56	196	364	3093	7.67	19.02	2.87	16.75	80.37
26	1994	ISU	3	5.8	52	132			6.9				
27	1995	ISU	3	6	64	165			7				
28	1996	ISU	3	5.76	81	173			7				
29	1997	ISU	3	6.72	107	245			7.2				
30	1998	ISU	3	5.94	80	160			7				
31	2000	Kinsey	8	6	176	1320	760	3187	6.8	27.93	12.12	22.68	57.05
32	2000	Kinsey	2	5.8	256	854	681	3881	7.3	28.67	7.64	19.79	67.68
33	2001	A&L	4	4.5	61	159	373	3391	7.7	20.53	2.23	15.42	82.35
34													
35													

Table 2-4

CEL%.XLS

	A	B	C	D	E	F	G
1	Corn Ear Leaf Percent						
2	C-SB-C-O-H Rotation, Manure/Bio-Solids Program						
3							
4	Year	Fertility	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
5	1984-Ridge Till	Compost/Spring	2.31	0.26	1.38	0.82	0.43
6	1985-Ridge Till	Manure/Spring	3.18	0.24	1.11	0.95	0.64
7	1986-Ridge Till	Manure/Spring	2.53	0.29	1.63	0.67	0.38
8	1987-Ridge Till	Bunker Manure/Spring	3.41	0.31	1.16	1.07	0.67
9	1988-Ridge Till	Bunker Manure/Spring	3.22	0.34	1.33	0.88	0.42
10	1989-Ridge Till	Bunker Manure/Spring	3.36	0.28	1.41	1.00	0.51
11	1990-Ridge Till	Bunker Manure/Spring	3.17	0.31	1.70	0.86	0.26
12	1991-Ridge Till	Bunker Manure/Spring	2.51	0.21	1.18	0.68	0.54
13	1994-Fall Moldboard Plow	Bunker Manure/Fall	2.80	0.30	1.90	0.78	0.25
14	1994-Ridge Till	Bunker Manure/Spring	2.88	0.28	1.54	0.86	0.30
15	2001 Spring Moldboard	Bunker Manure/Fall	3.53	0.39	2.00	0.91	0.39
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

Table 2-5

BSHM.XLS

	A	B	C	D	E	F	G	H	I	J	K	L
1						**Bio Solids Heavy Metals Loading**						
2												
3	Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
4	Dry Tons Delivered	353	335	268	209	241	270	284	279	319	314	365
5	**Arsenic mg/kg**				2.54	2.17	2.8	3.1		4.1	3.3	4.2
6	Pounds per acre	0.005	0.007	0.009	0.004	0.004	0.006	0.007	0.01	0.01	0.009	0.012
7	Cum. #/A.	0.005	0.012	0.021	0.025	0.029	0.035	0.042	0.052	0.057	0.071	0.083
8	**Cadmium mg/kg**				7.74	3.48	5.53	4.6		3.7	3.5	3.5
9	Pounds per acre	0.011	0.015	0.012	0.013	0.007	0.012	0.01	0.009	0.009	0.009	0.01
10	Cum. #/A.	0.011	0.026	0.038	0.051	0.058	0.07	0.08	0.089	0.098	0.107	0.117
11	**Chromium mg/kg**				1959.09	1413.4	1454.71	1263		460	765	460
12	Pounds per acre	3.695	3.44	5.206	3.174	2.63	3.026	2.753	1.53	1.132	1.989	1.288
13	Cum. #/A.	3.695	7.135	12.341	15.515	18.145	21.171	23.924	25.454	26.586	28.575	29.863
14	**Copper mg/kg**				1178.5	890.5	794.75	933		437	685	645
15	Pounds per acre	0.954	1.435	2.19	1.909	1.656	1.653	2.034	1.943	1.075	1.781	1.806
16	Cum. #/A.	0.954	2.389	4.579	6.488	8.144	9.797	11.831	13.774	14.849	16.63	18.436
17	**Lead mg/kg**				19.95	200.25	22.88	203		243	147	188
18	Pounds per acre	0.331	0.39	0.438	0.345	0.373	0.467	0.443	0.345	0.598	0.382	0.526
19	Cum. #/A.	0.331	0.721	1.159	1.504	1.877	2.344	2.787	3.132	3.73	4.112	4.638
20	**Mercury mg/kg**				3.05	3.98	1.7	1.5		1	1.1	1
21	Pounds per acre	0.015	0.005	0.009	0.005	0.007	0.004	0.003	0.002	0.002	0.003	0.003
22	Cum. #/A.	0.015	0.02	0.029	0.034	0.041	0.03	0.048	0.05	0.052	0.055	0.058
23	**Molybdenum mg/kg**										8.2	5.3
24	Pounds per acre										0.021	0.015
25	Cum. #/A.										0.021	0.036
26	**Nickel mg/kg**				19.95	19.93	22.88	18.6		23	14	16
27	Pounds per acre	0.073	0.054	0.056	0.032	0.037	0.048	0.041	0.036	0.057	0.036	0.045
28	Cum. #/A.	0.073	0.127	0.183	0.215	0.252	0.3	0.341	0.377	0.434	0.47	0.515
29	**Selenium mg/kg**									6.7	6.1	8.5
30	Pounds per acre										0.016	0.024
31	Cum. #/A.										0.016	0.04
32	**Zinc mg/kg**				212.75	580.75	224.5	486		353	420	358
33	Pounds per acre	0.797	1.241	1.744	1.266	1.08	1.077	1.059	0.937	1.092	1.092	1.002
34	Cum. #/A.	0.797	2.038	3.782	5.048	6.128	7.205	8.264	9.201	10.293	11.385	12.387
35												
36												

Table 2-6

BSHM.XLS

	A	M	N	O	P	Q	R	S	T	U	V
1											
2											
3	Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
4	Dry Tons Delivered	231	414	234	243	304	383	352	334	378	232
5	**Arsenic mg/kg-As**	6.9	4.3	3.3	4.5	7.1	4.4	8.9	29.8	14.6	4.9
6	Pounds per acre	0.012	0.014	0.006	0.008	0.017	0.014	0.025	0.78	0.044	0.009
7	Cum. #/A.	0.095	0.109	0.115	0.123	0.14	0.154	0.179	0.257	0.301	0.31
8	**Cadmium mg/kg-Cd**	3.2	4.9	6.6	3.6	4.9	3.1	3.2	6.1	3.7	2
9	Pounds per acre	0.005	0.016	0.012	0.006	0.012	0.009	0.008	0.013	0.015	0.009
10	Cum. #/A.	0.122	0.138	0.15	0.156	0.168	0.177	0.185	0.198	0.213	0.222
11	**Chromium mg/kg-Cr**	563	528	522	160	338	668	683	1475	900	1318
12	Pounds per acre	1.002	1.679	0.94	0.288	0.811	2.004	1.912	3.835	2.61	2.35
13	Cum. #/A.	30.865	32.544	33.484	33.772	34.583	36.587	38.499	42.334	44.944	47.294
14	**Copper mg/kg-Cu**	695	868	1258	1400	1003	733	260	238	218	430
15	Pounds per acre	1.237	2.76	2.264	2.52	2.407	2.199	0.728	0.624	0.638	0.765
16	Cum. #/A.	19.673	22.433	24.697	27.217	29.624	31.823	32.551	33.175	33.813	34.578
17	**Lead mg/kg-Pb**	198	155	85	196	423	146	102	116	94	53
18	Pounds per acre	0.352	0.493	0.153	0.353	1.015	0.438	0.286	0.299	0.276	0.098
19	Cum. #/A.	4.99	5.483	5.636	5.989	7.004	7.442	7.728	8.027	8.303	8.401
20	**Mercury mg/kg-Hg**	<1	<1	<1	1.1	1	1.1	1	0.9	0.8	1
21	Pounds per acre	0.002	0.003	0.002	0.002	0.002	0.003	0.003	0.013	0.015	0.009
22	Cum. #/A.	0.06	0.063	0.065	0.067	0.069	0.072	0.075	0.088	0.103	0.112
23	**Molybdenum mg/kg**	5.8	10.8	13	8.6	10	8.4	10.3	17.8	25.7	11.7
24	Pounds per acre (Mo)	0.011	0.035	0.023	0.015	0.024	0.026	0.029	0.052	0.073	0.018
25	Cum. #/A.	0.047	0.082	0.105	0.12	0.144	0.17	0.199	0.251	0.324	0.342
26	**Nickel mg/kg-Ni**	16	18	18	26	17	32	33	31.5	41.5	32
27	Pounds per acre	0.028	0.057	0.032	0.047	0.041	0.096	0.092	0.078	0.116	0.053
28	Cum. #/A.	0.543	0.6	0.632	0.679	0.72	0.816	0.908	0.986	1.102	1.155
29	**Selenium mg/kg-Se**	8.3	9	6.5	11	14	8.4	13.9	29.5	21.1	10
30	Pounds per acre	0.015	0.029	0.012	0.02	0.034	0.026	0.039	0.078	0.058	0.018
31	Cum. #/A.	0.055	0.084	0.096	0.116	0.15	0.176	0.215	0.293	0.351	0.369
32	**Zinc mg/kg-Zn**	350	455	1594	1585	1175	510	248	238	185	363
33	Pounds per acre	0.623	1.447	2.869	2.853	2.82	1.53	0.694	0.624	0.537	0.65
34	Cum. #/A.	13.01	14.457	17.326	20.179	22.999	24.529	25.223	25.847	26.384	27.034
35											
36											

Table 2-6

BSHM.XLS

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
1	Dry Tons per acre			1.18	9.8	**Maximum**						
2	Field Number		1--5	all fields	5	**Loading**						
3	Year	2005	2006	2007	2008	**Lbs. /acre**						
4	Acres applied			260	38.48							
5	Dry Tons Delivered	316	293	307	377							
6	**Arsenic mg/kg-As**	3.5	1.8	1.3								
7	Pounds per acre	0.009	0.005	0.004	0.047							
8	Cum. #/A.	0.319	0.324	0.328		**36**						
9	**Cadmium mg/kg-Cd**	2	1.8	2								
10	Pounds per acre	0.005	0.005	0.005	0.039							
11	Cum. #/A.	0.227	0.232	0.237		**34**						
12	**Chromium mg/kg-Cr**	1010	185	218								
13	Pounds per acre	2.464	0.418	0.515	4.273							
14	Cum. #/A.	49.758	50.176	50.691		**2670**						
15	**Copper mg/kg-Cu**	465	573	518								
16	Pounds per acre	1.135	1.295	1.223	8.193							
17	Cum. #/A.	35.713	37.008	37.231		**1335**						
18	**Lead mg/kg-Pb**	45	39	33								
19	Pounds per acre	0.11	0.088	0.078	0.549							
20	Cum. #/A.	8.511	8.599	8.677		**267**						
21	**Mercury mg/kg-Hg**	1	1.2	1.2								
22	Pounds per acre	0.002	0.002	0.002	0.02							
23	Cum. #/A.	0.114	0.116	0.118		**15**						
24	**Molybdenum mg/kg**	19.3	18	14								
25	Pounds per acre (Mo)	0.048	0.041	0.033	0.137							
26	Cum. #/A.	0.39	0.431	0.464		**66**						
27	**Nickel mg/kg-Ni**	32	62	15								
28	Pounds per acre	0.078	0.14	0.035	0.245							
29	Cum. #/A.	1.233	1.373	1.408		**373**						
30	**Selenium mg/kg-Se**	11	14	12								
31	Pounds per acre	0.027	0.032	0.028	0.176							
32	Cum. #/A.	0.396	0.428	0.456		**89**						
33	**Zinc mg/kg-Zn**	320	358	273								
34	Pounds per acre	0.781	0.809	0.644	5.292							
35	Cum. #/A.	27.815	28.624	29.268		**2490**						

Table 2-6

NLOADING.XLS

	A	B	C	D	E	F
1	**Nitrogen Loading - Manure/Bio Solids**					
2	Manure/Bio Solids analysis, seven year average					
3	TKN = 3.08%					
4	Ammonia Nitrogen = .98% X 2000 = 19.60# per ton					
5	Nitrate Nitrogen = <0.10%					
6	TKN - Ammonia Nitrogen = Organic Nitrogen = 2.1% X 2000 = 42# per ton					
7		# Nit. per	Appl. rate	# Nit. per	Amount	# Nit. per
8		ton	tons/acre	acre	available	acre
9	**Corn Fertilization**					
10	Fall application following hay, plowed under and rye broadcast.					
11	Ten ton load every two rows - 52.6 wet tons per acre X 15% DM = 7.89 dry T/A.					
12	**Corn after hay**					
13	Organic nitrogen	42.00	7.89	331.38	0.35	115.98
14	Ammonia nitrogen	19.60	7.89	154.64	0.50	77.32
15	One year legume/grass hay					0.00
16	4% organic matter release					110.00
17	Total nitrogen					303.31
18	Corn crop removal					**305.00**
19	**Soybean Fertilization-none**					
20	Last year organic nitrogen	42.00	7.89	331.38	0.18	59.65
21	4% organic matter release					110.00
22	Total nitrogen					169.65
23	Soybean crop removal					**339.00**
24	**Corn Fertilization**					
25	Spring application covered with ridge-till planter,					
26	Ten ton load every 4 rows, 26.32 wet tons/acre X 15% DM = 3.95 dry T/acre					
27	Organic nitrogen	42.00	3.95	165.90	0.35	58.07
28	Ammonia nitrogen	19.60	3.95	77.42	0.50	38.71
29	4% organic matter release					110.00
30	Soybean contribution					66.00
31	Previous organic nitrogen	42.00	11.84	497.28	0.09	44.76
32	Total nitrogen					317.53
33	Corn crop removal					**225.00**
34	**Oat Fertilization - no add.**					
35	4% organic matter release					110.00
36	Previous organic nitrogen	42.00	11.84	497.28	0.09	44.76
37	Total nitrogen					154.76
38	Oat crop removal					**145.00**
39	**Hay Fertilization - no add.**					
40	4% organic matter release					110.00
41	Previous organic nitrogen	42.00	11.84	497.28	0.09	44.76
42	Total nitrogen					154.76
43	Hay crop removal					**530.00**
44						
45	Grand total					1099.99
46						
47	**Five year nitrogen loading**					
48	Organic nitrogen	42.00	11.84	497.28	0.95	472.42
49	Ammonia nitrogen	19.6	11.84	232.06	0.5	116.03
50	4% organic matter release X 5					550
51	Total nitrogen available from the soil					1138.45
52						
53	Nitrogen removed in 5 years					**1544.00**

Table 2-7

FERTSUMM.XLS

	A	B	C	D	E	F	G	H	I	J	K	L
1	Purchased Fertility for 33 Corn Experiments											
2	Manure\Bio-solids is the basis of the fertility program.											
3												
4							-------------------------- Planter Liquids --------------------------					
5		-------- Cultivator Side-Dress Nitrogen ----------					71B	3/10/10	----------------- Agro-Culture ----------------			
6	Year	1987	1987	1988	1988	1989	1986	1987	1990	1991	1992	1992
7	Field #	2	3	1	4D	2	5	2	3C	1S	2S	3C
8	Comments							tube plug				
9	Placement						under	under	side	side	side	side
10	Pounds per acre	80	50	64	63	60	3+6+3	3+10+10	6+14+13	8+17+18	45+14+13	45+14+13
11	Control Bu/A	136.9 a	113.1 a	111.7 a	107.1 a	140.2 a	143.1 a	116.5 a	111.2 a	112.0 a	180.0 a	165.9 a
12	Fertilizer Bu/A	136.9 a	110.4 a	111.7 a	104.0 a	142.0 a	144.0 a	123.7 a	116.0 b	114.0 a	184.7 a	178.6 b
13	Fert. Return $A	-12.00	-7.50	-9.60	-9.45	-12.00	-13.50	-7.20	-27.66	-43.39	-46.36	-23.77
14												
15		---Planter Liquids---										
16		------------------------------------ Liquid Grow 2-6-12 ------------------------------------							Planter Suspensions		2/6/12	Dry PK
17	Year	1993	1993	1993	1993	1994	1994	1994	1992	1992	1995	1995
18	Field #	1	1	1	4D	2	2	2	2S	3C	4C	4D
19	Comments	rye-wet	rye-wet	rye-wet	FM/MP-92	No M-94	Sp. M-94	Fall M-93			FM/MP-92	FM/MP-92
20	Placement	2" below	2" below	2" below	2" below	2" below	2" below	2" below	side	side	2" below	FDB
21	Pounds per acre	20+14+27	26+19+35	34+23+46	20+14+27	28+19+38	28+19+38	28+19+38	50+15+45	50+15+45	8+23+46	0+30+60
22	Control Bu/A	56.9 a	56.9 a	56.9 a	88.3 a	165.9 a	170.0 a	170.9 a	180.0 a	165.9 a	155.3 a	153.7 a
23	Fertilizer Bu/A	70.6 b	69.4 b	74.9 b	91.3 a	170.0 a	171.0 a	173.8 a	184.7 a	191.0 c	158.1 ab	159.5 b
24	Fert. Return $A	21.72	17.11	10.47	-16.44	-23.62	-23.62	-23.62	-17.91	26.78	-24.26	-3.19
25												
26		------------------ Planter Potassium ------------------					-------------------------- Planter Dry NPK -----------------------------					
27		KCL	K2SO4	KCL	KCL	K2SO4						
28	Year	1986	1986	1986	1988	1988	1988	1990	1991	1991	1991	1992
29	Field #	1	1	5	1	1	6	3C	1S	5E	5E	2S
30	Comments				Dry	Dry	Dry					
31	Placement	side	side	side	side	side	side	side	side	side	side	side
32	Pounds per acre	0+0+30	0+0+30	0+0+30	0+0+60	0+0+30	9+23+60	26+18+59	40+0+60	26+18+60	56+18+60	50+15+45
33	Control Bu/A	95.3 a	95.3 a	103.1 a	114.2 a	114.2 a	92.6 a	111.2 a	112.0 a	121.7 a	121.7 a	180.0 a
34	Fertilizer Bu/A	118.0 b	115.0 b	117.2 b	117.2 b	115.0 a	93.7 a	120.0 c	113.4 a	121.9 a	124.2 a	189.0 b
35	Fert. Return $A	39.58	28.54	23.54	1.03	-8.10	-13.00	0.54	-16.29	-16.83	-23.20	-5.07
36												

Table 2-8

Sbfertsu.xls

	A	B	C	D	E	F	G	H	I	J	K	L
1				**Purchased Fertility for Soybean Experiments**								
2				**Manure/Bio Solids is the basis of the fertility program**								
3												
4		---------------------- Dry Planter Fertilizer -------------------------					----------------------------- Planter Liquids ---------------------------------					
5		KCL	KCL	K2SO4	KCL	NPK	71B	Agro-Cult	Agro-Cult	Suspension	Liq. Grow	Liq. Grow
6	Year	1986	1987	1987	1991	1992	1986	1990	1992	1992	1994	1995
7	Field #	3	1	1	3C	1S	7	5W	3C	1S	4C	5
8	Comments							6.9sb/ft				FM/MP-93
9	Placement	Side	Side	Side	Side	Side	Under	Under	Side	Side	2" Below	2" Below
10	Pounds per acre	0+0+30	0+0+30	0+0+30	0+0+60	3+15+60	3+6+3	6+14+13	8+18+17	3+15+60	8+23+46	8+23+46
11	Control Bu/A	37.7 a	49.9 a	49.9 a	49.2 a	59.2 a	50.9 a	48.6 a	49.2 a	59.2 a	69.5 a	59.45 b
12	Fertilizer Bu/A	40.8 b	52.3 b	52.1 b	51.2 b	59.5 a	48.6 b	46.5 b	49.6 a	59.7 a	68.7 a	61.52 a
13	Fert. Return $/A	12.36	8.56	2.21	1.80	-12.43	-24.47	-40.03	-43.39	-14.33	-22.28	-9.50
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Table 2-9

manure practices for corn.xls

	A	B	C	D	E	F	G	H	I
1	**Manure Practices for Corn**								
2	R.T. = Ridge tillage								
3	MBP = Moldboard plow								
4			Previous	Manuring			Planting	Yields	
5	Year	Field #	Crop	Date	Rate	Tillage	Date	Bu./A.	Comments
6					Dry Tons/A.				
7	1992	3	Soybeans	Spring	2	R.T.	5/10/1992	190	
8	1993	1	Soybeans	Spring	2	R.T.	5/20/1993	72	Too much rye cover-flood
9	1993	4CD	Hay	Fall	4	MBP	5/21/1993	90	Flood
10	1993	8	Pasture	Fall	4	MBP	5/28/1993	107	Flood
11	1994	5	Hay	Fall	8	MBP	4/27/1994	155	Leaf blight
12	1994	6	Pasture	None	None	MBP	5/2/1994	172	
13	1994	2	Soybeans	Spring	4	R.T.	5/7/1994	171	
14	1995	4D	Soybeans	Spring	8	R.T.	5/18/1995	160	
15	1995	3	Hay	Fall	8	MBP	5/17/1995	179	
16	1996	1	Hay	Fall	4	MBP	5/7/1996	170	
17	1996	9	Pasture	None	None	MBP-5/1/96	5/8/1996	179	
18	1996	5	Soybeans	Spring	8	R.T.	5/6/1996	171	
19	1997	3	Soybeans	4/26/1996	4	R.T.	5/5/1996	148	
20	1997	4D	Oats	9/18/1996	8	MBP-9/21/96	5/6/1997	161	Excellent rye cover
21	1997	4C	Oats	9/29/1996	8	MBP-10/3/96	5/6/1997	161	Very poor rye cover
22	1998	2	Hay	11/20/1997	8	MBP-11/26/97	5/4/1998	181	
23	1998	7	Pasture	None	None	KVP-4/27/98	5/5/1998	147	
24	1998	1	Soybeans	4/28/1998	4	R.T.	5/6/1998	164	
25	1999	5	Hay	11/23/1998	8	KVP-11/27/98	5/26/1999	143	planted late, low pop.
26	1999	4	Soybeans	4/15/1999	4	R.T.	5/19/1999	139	planted late, low pop.
27	2000	3	Hay	11/7/1999	8	KVP-11/25/99	4/30/2000	153	
28	2000	2	Soybeans	4/19/2000	4	R.T.	4/27/2000	135	K short, poor stand, low gr
29	2000	8	Pasture	none	none	Fall Chisel	4/28/2000	159	Dry,very weedy,C.T.
30	2001	4	Oats	11/12/2000	8	KVP-4/21/01	5/9/2001	147	
31	2001	5	Soybeans	4/25/2001	4	R.T.	5/15/2001	138	Hard rain west, poor stand
32	2002	1	Hay	11/20/2001	0-8-16	KVP-11/22/01	5/6/2002	176	
33	2002	3	Soybeans	5/4/2002	4	R.T.	5/7/2002	177	
34	2002	6	Pasture	none	none	Fall Chisel	5/5/2002	181	nice corn, clean
35	2003	2	Hay	11/15/2002	0-8-16	11/20/2202	5/13/203	193	only one cultivation
36	2003	4	Soybeans	Apr-03	4	R.T.	5/18/2003	192	
37	2004	1	Soybeans	None	0	R.T.	5/1/2004	209	Aug. wind, some lodging
38	2004	5	Hay	Sept 13-24	0-8-16	KVP-11/26/03	4/29/2004	216	Aug. wind, lodging bad
39	2004	9	Pasture	None	0	Fall Chisel	4/29/2004	194	Aug. wind, some lodging
40	2005	3	Hay	29-Sep	0-8-16	KVP-Oct. 10	5/6/2005	231	
41	2005	2	Soybeans	None	0	R.T.	4/25/2005	203	
42	2006	4	Hay	Oct. 1	0-8-16	KVP-Oct. 6	5/6/2006	190	
43	2006	5	Soybeans	None	0	R.T.	5/7/2006	186	
44	2007	1	Hay	20-Sep	0-8-16	KVP-Oct1	5/12/2007	205	
45	2007	3	Soybeans	None	0	R.T.	5/13/2007	219	
46	2008	2	Hay	15-Sep	0-8-16	KVP-Sept.20	5/6/2008	228	
47	2008	4	Soybeans	None	0	R.T.	5/20/2008	198	
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Table 2-10

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