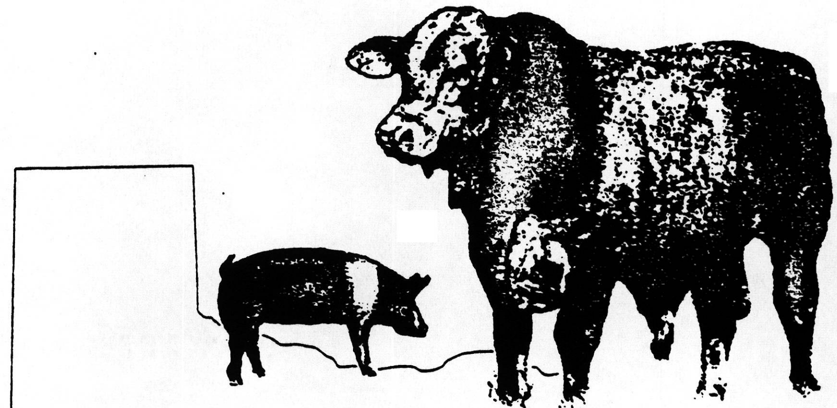
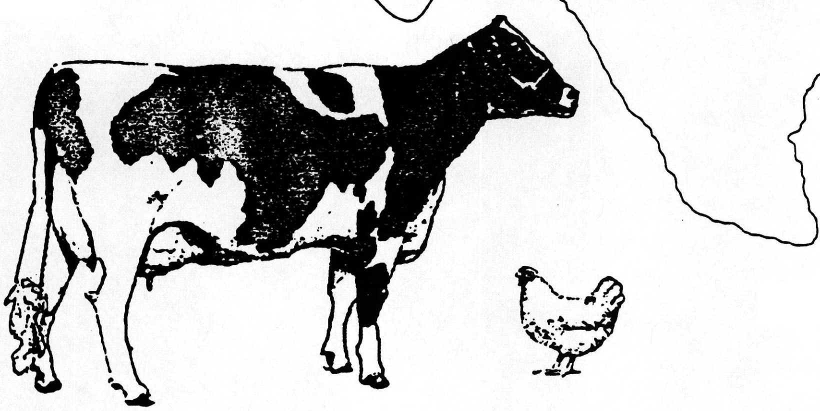


INNOVATIONS AND NEW HORIZONS IN LIVESTOCK AND POULTRY MANURE MANAGEMENT



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LAND APPLICATION OF POULTRY LITTER AND EFFLUENT IN EAST TEXAS

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ABSTRACT

A major problem for producers of poultry food products in Texas is the disposal of waste generated by millions of birds. Scientists at the Texas A&M University Agricultural Research and Extension Center at Overton are conducting research to evaluate disposal and use of manure wastes from broiler and egg production systems as sources of nutrients for forage and vegetable crops. Results of research show that poultry wastes are good sources of plant nutrients for these crops when used in moderation. Four tons of poultry litter applied per acre in a single application in spring has produced good crop yields with the least increase in soil nitrate and phosphorus. Continued annual applications of four tons/acre cause excessive increases in soil nitrate-nitrogen and phosphorus. Four tons of poultry litter/acre for the first harvest in spring followed by supplemental nitrogen and potash for succeeding cuttings is suggested for high nitrogen requirement crops such as hybrid bermudagrasses in high rainfall, temperate climates of Texas. Split application of the total amount of poultry litter, half in spring and half in fall, caused the least increase in soil phosphorus concentration. Hen effluent applied at a rate to supply approximately 70 lb of N/acre/regrowth appeared adequate for cool season ryegrass production.

INTRODUCTION

Poultry production in the U.S. increased 27-28% to about 30 billion pounds from 1990 to 1995. Much of this increase has been in Texas where broiler production increased 50% from 1986 to 1992 (Agricultural Statistics Board, USDA). In the U.S., per capita consumption of meat from poultry increased from 37 lb in 1973 to 78 lb in 1993. The growing export market to Hong Kong, former USSR countries, and Japan accounted for 10% of the total production in 1994. In 1994, the value of poultry production in Texas was $941.7 million with the value of broiler production increasing at an annual rate of 10% since 1987. The poultry meat and egg industry is a major contributor to the Texas economy and a source of jobs. The continued increase of the poultry industry in Texas is dependent on the environmentally safe and profitable disposal of wastes and litter from production operations.

Poultry manure has always been considered a prime source of nutrients for plant growth. Poultry wastes contain higher concentrations of nitrogen (N), phosphorus (P), and calcium (Ca) than wastes of other animal species. A recent survey of broiler litter in northeast Texas showed an average

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nutrient content of 2.95% N, 1.64% P, 2.36% potassium (K), 2.03% Ca, 0.51% magnesium (Mg) and high concentrations of micronutrients (unpublished data). The quantity of nutrients is variable due to feed mix, the number of batches of broilers raised on the litter, and poultry house management practices.

Broiler litter as a plant nutrient source provides slow release N that decreases nitrate leaching, contains other plant nutrients besides N, P and K, contains Ca compounds that reduce soil acidity, and adds organic matter that improves water and nutrient holding capacity of the soil. Sufficient animal waste should be applied to provide only the amounts of plant nutrients needed by the crop for one season. However, the ratio and variability of broiler litter nutrient concentrations do not match crop requirements and are site specific. When broiler litter is applied to meet the N requirements of grasses, excess P, K, and Mg increase in soils.

Flush and lagoon waste handling systems for caged layer manure were implemented over the past two decades. These systems were developed on caged layer farms primarily to reduce labor, fly, and odor problems. Evaporation and recirculation of ponded effluent to clean the manure channels without adequate irrigation withdrawal and replenishment with fresh water leads to increased salinity and ammonia-nitrogen that limits the ability of operations to achieve environmentally sustainable disposal practices.

Primary environmental concerns of applying poultry wastes are nitrate leaching into ground water and increased P levels in the soil surface that can move into surface water by particulate transport. Research on poultry wastes as an efficient and environmentally safe source of nutrients for crops is being conducted at the Texas A&M University Agricultural Research and Extension Center at Overton. Developing environmentally sound poultry litter management practices for sustainable cropping systems.

A three-year study was initiated in 1992 to investigate the feasibility of growing warm- and cool-season annual forage crops to remove excess nutrients supplied by poultry litter in rotational-cropping vegetable systems. Treatments consisted of cropping systems of vegetables in spring and fall, a forage crop in spring with vegetables in fall, and vegetables in spring with forage in fall. Poultry litter was applied at one or two times the recommended rate in the spring, fall, or spring and fall. Rates were based on N requirement of the crop and percent N in the litter. Poultry litter treatments were compared to fertilizer blends applied according to crop needs based on a soil test, and to a control treatment containing no commercial fertilizer or poultry litter. The amount of P applied in the fertilizer blends was much lower than the P applied as a plant nutrient in the poultry litter. Treatments were incorporated immediately after application by roto tilling. Tomatoes were the spring vegetable followed by turnips in fall. Sorghum-sudan was the spring forage with Elbon rye planted in fall. Data were obtained on nitrate-N (NO_3-N) and P accumulation and leaching.

Results

Litter rate, cropping system, and season of application influenced NO_3-N leaching and accumulation. At the end of the fall season of 1992, poultry litter rate of application had no effect on the NO_3-N content of the surface 30 cms of soil (Fig. 1). Leaching and accumulation of NO_3-N increased in the soil by the end of the fall season in 1994 as the rate of poultry litter application increased from 1X to 2X with the greatest increase being from the fertilizer blend.

Tomatoes in spring followed by Elbon

rye in fall reduced leaching of NO_3-N by the end of the first year compared to the other two cropping systems (Fig. 2). This trend continued through the end of the study. The largest amount of leaching and accumulation at the 122 cm (4 ft) depth was from a cropping system of spring and fall vegetables.

The fertilizer blend applied in both spring and fall caused the greatest leaching and accumulation of NO_3-N at the end of the first year (Fig. 3). By the end of the study, litter and fertilizer blend applied in both spring and fall showed the greatest amount of NO_3-N leaching and accumulation. The least amount of leaching was due to a single application in spring or fall.

Poultry litter rate, cropping system, and season of application influenced residual soil P accumulation. Data from the end of the first year indicated that doubling the recommended litter rate increased P accumulation in the surface 15 cm (6 in) of soil (Fig. 4). By the end of the study, P accumulation was increased by both litter rates. The least amount of P accumulation in this study was due to the commercial fertilizer blend. At the beginning of the study, a system of planting a spring cover followed by a fall vegetable crop produced the greatest accumulation of P in the surface 15 cm of soil (Fig. 5). By the end of the study, P accumulation was increased in all cropping systems. In the first year, litter applied in spring or fall increased P accumulation when compared to fertilizer blend treatments applied in both spring and fall, or spring or fall only application (Fig. 6). For the duration of this study, fall application of litter produced the highest increase in soil P.

Application

Results show that application of poultry litter in the spring based on soil test recommendations in a system of spring vegetables followed by fall cover crop decreased NO_3-N leaching. The use of poultry litter as a source of plant nutrients, if applied in an environmentally sound manner, will be less of a threat to NO_3-N pollution of ground water than use of similar rates of N in commercial fertilizer. Applying poultry litter at rates sufficient to meet crop needs for N, regardless of the cropping system used or season of application, results in P accumulation that can lead to non-point source pollution of surface waters.

Legumes need more P than do grasses. The advantage of using legumes for removing excess P is that no additional N fertilizer has to be applied since properly inoculated legumes can obtain N from the atmosphere through N_2 fixation. A study was initiated in spring 1995 to evaluate use of warm- and cool-season legumes in rotational vegetable cropping systems to remove excess P supplied by poultry litter used as a nutrient source.

Use of poultry litter as a nutrient source for 'Coastal' bermudagrass pasture

Four and 8 tons of poultry litter/acre applied in single or split application were compared to 0, 100, 200, and 400 lb of N per acre, split in two applications on 'Coastal' bermudagrass (*Cynodon dactylon* (L.) Pers.). Phosphorus and K were applied with the N fertilizer treatments as a N-P_2O_5-K_2O ratio of 3-1-2.

Results

There was a 10% yield advantage when all PL was applied in late spring *vs* splitting it into two equal applications in 1992 (Table 1). Temperature and moisture conditions are more favorable for Coastal bermudagrass growth in late spring than in mid-summer. Application of all the poultry litter in spring allowed more of the plant nutrients to be available to the grass during the period of optimum bermudagrass growth.

Applying 8 tons (344 lb estimated available N) and 4 tons (172 lb estimated available N) of poultry litter in late spring produced yields comparable to applying 400 and 200 lb of N fertilizer in split applications. Slower release of the organic form of N from poultry litter during the growing season is an advantage. Most of the fertilizer N is available immediately, therefore is subject to more rapid leaching, particularly on sandy soils. Nitrogen use efficiency (lb forage produced per lb N applied) decreased as N rate increased.

Poultry litter used in 1993 contained only 42 lb N/ton. This made the 8 (258 lb N/acre) and 4 ton/acre (129 lb N/acre) rates similar to the 200 and 100 lb rates of fertilizer N. This demonstrates the variability in nutrient content among poultry farms. As in 1992, applying poultry litter in a single, spring application instead of two split applications produced higher yields and (Table 2). After 2 years, soil pH had dropped to 5.0 in plots treated with 400 lb N/acre/year (Table 3). Nitrification of ammonium forms of nitrogen by the nitrosomonas and nitrobacter organisms in the soil creates acidity. Application of 800 lb of N/acre as ammonium nitrate produces acidity that must be neutralized by the equivalent of 1440 pounds of calcium carbonate.

Although not significant, plots receiving poultry litter had a slightly higher pH than plots treated with the N fertilizer. Low levels of NO_3-N were found in all plots. Concentrations of salt, P, K, and Mg were significantly higher in the poultry litter treated plots than in N fertilizer treated plots. These data support the concept that when poultry litter is the only source of applied plant nutrients, P and K in excess of bermudagrass needs will accumulate in the soil. This is especially true of P. A lower P concentration occurred in soils when the 8 t/acre rate of poultry litter was split-applied compared to a single application of the total amount of poultry litter.

Application

Poultry litter is a good source of nutrients for warm-season, perennial forages like hybrid bermudagrasses. Poultry litter contains readily available and slow release sources of N, supplies additional nutrients P, K, Ca, Mg, S, and micronutrients, adds organic matter, and after several years of annual applications will raise soil pH. Disadvantages of poultry litter as a reliable nutrient source are variability in nutrient content, temporary odor during storage and after application, transportation costs that prohibit moving it long distances, and an excess concentration of soil P if high rates are applied. Under a hay harvest situation, 3 to 4 tons of poultry litter/acre should be applied in April followed with additional commercial N and K fertilizer after the second and succeeding harvests. Only about 2 ton of poultry litter/acre should be applied under grazing conditions because of nutrient recycling through the animal. Soil samples should be analyzed annually in both forage systems to monitor residual soil nutrients and adjust poultry litter and/or commercial fertilizer applications to allow plants to use any excess nutrient buildup in the soil.

Evaluation of lagoon effluent from caged laying hens as a nutrient source for ryegrass pasture.

Many caged layer operations in the southeastern U.S. dispose of holding pond effluent from egg production houses by irrigation onto farm fields. Frequent irrigation of individual fields by center-pivot application can lead to excessive buildup of salts and plant nutrients, particularly nitrogen (N) and phosphorus (P). Nitrate-N in soil will move readily with water. Inorganic P fertilizer remains in the soil surface. Some of the P in poultry effluent is in organic forms. Evidence of P movement below the surface 6-inch depth exists in some fields in East Texas due to excess application of effluent or poultry litter. This study was designed to evaluate ryegrass response to application of lagoon effluent from caged layer houses and to determine nutrient concentrations in run-off water leaving these plots during precipitation events in excess of the infiltration capacity of the soil. Effluent was applied at rates equivalent to 0, 69, and 137 lb of N/acre on selected plots of ryegrass in a Bowie fine sandy loam. These treatments were applied for each harvest of ryegrass.

Results

Analysis of a sample of effluent is shown in Table 4. The $N-P_2O_5-K_2O$ ratio in this effluent is 9-2.3-20. The salt content measured as electrical conductivity was 19.1 mmhos/cm. The sodium adsorption ratio (SAR) was 15.2. Use of this effluent as a nutrient source for crop plants can cause harmful buildups of salt and sodium on soils with inadequate drainage. Even with adequate drainage, special management for salinity control may be required. Plants with good salt tolerance should be selected. Chemical amendments such as gypsum may be needed to replace harmful levels of sodium.

Effluent at a rate of 69 lb of N/acre applied February 23, April 6, and May 10, 1995 produced more than 3 tons of ryegrass/acre in three cuttings (Table 5). Effluent applied at double this rate produced statistically similar, but slightly lower dry matter yield.

Application

Hen effluent as an occasional application appears to be a good source of nutrients for forage crops grown on well-drained and permeable soils in high rainfall regions. Effluent with these salt and sodium concentrations is not a good source of water for routine irrigation. Where hen effluent is used as a nutrient source for crops, routine sampling and analysis of field soils should be done to monitor increasing nutrient levels and increases in salinity and sodium.

Most crop plants are tolerant to salinity levels below 2 to 4 mmhos. Selected forages such as alfalfa, sweetclovers, and bermudagrasses can tolerate higher levels of salinity. Plant species vary greatly in the amounts of sodium that they may accumulate.

Sodium in the soil may exert important secondary effects on plant growth through adverse structural modifications of the soil. If the exchange complex of the soil contains appreciable amounts of sodium, the soil may become dispersed and puddled, thereby causing poor aeration and low water availability. If the exchange complex becomes more than 40 to 50 percent saturated with sodium, nutritional disturbances in plants may result.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance, support and cooperative efforts of Dr. John Sweeten, Professor and agricultural engineer with the Texas Agricultural Extension Service and Dr. Clyde Munster, Assistant Professor and agricultural engineer with the Texas Agricultural Experiment Station in College Station; Mr. James V. Davis, research associate and Mr. Allen Leonard, research assistant in soils research, and Mrs. Amanda Davidson and Mr. David Doctorian, technicians II in the forage physiology and management program at the Texas Agricultural Experiment Station at Overton, Texas.

Table 1. Comparison of poultry litter and commercial fertilizer on Coastal bermudagrass production in 1992.

Treatment (per acre)	Available N[1] lb/acre	Yield lb DM/acre	N efficiency[2] lb DM/lb N
8 ton PL	344	9811	14.6
400 lbs N	400	9636	12.2
4 ton + 4 ton PL	344	8850	11.8
200 lb N	200	8679	19.5
4 ton PL	172	8324	20.6
2 ton + 2 ton PL	172	7576	16.3
100 lb N	100	7137	23.6
0	-----	4774	----

[1] A ton of poultry litter contained 71 lb N, 115 lb P_2O_5, and 77 lb K_2O, assumed 60% availability of N first year.
[2]Yield/lb available N (yield difference between treatment and control (no N) divided by available N).
[3]Yields followed by the same letter are not significantly different at 0.05 level, Waller-Duncan MRT.

Table 2. Comparison of poultry litter and commercial fertilizer on Coastal bermudagrass production in 1993.

Treatment (per acre)	Available N[1] lb/acre	Yield lb DM/acre	N efficiency[2] lb DM/lb N
400 lb N	400	10,458 a[3]	16.0
8 ton PL	258	9,274 b	20.2
200 lb N	200	8,294 c	21.2
4 ton + 4 ton PL	258	7,838 cd	14.7
4 ton PL	129	7,451 d	26.3
2 ton + 2 ton PL	129	6,927 e	22.3
100 lb N	100	6,446 e	23.9
0	----	4,052 f	----

[1]A ton of poultry litter contained 42 lb N, 32 lb P_2O_5, and 48 lb K_2O, assumed 60% availability of poultry litter N from this year and 10% from last year.
[2]Yield/lb available N (difference between treatment and control (no N) divided by available N).
[3]Yields followed by the same letter are not significantly different at 0.05 level, Waller-Duncan MRT.

Table 3. Soil pH, salt concentration, and extractable nutrient concentrations in the top 15 cm of soil after 2 years of poultry litter (PL) or commercial fertilizer application.

Treatment (per acre)	pH	NO_3	Salinity	P	K	Na	Ca	Mg
No N	6.0 a[1]	1.0 c	52.5 d	3.5 d	81.8 c	20.8 a	558.5 a	48.0 b
100 lb N	5.8 a	1.5 abc	58.8 d	5.0 d	89.3 c	33.8 a	514.8 a	54.8 b
200 lb N	6.0 a	1.3 bc	55.0 d	4.3 d	89.8 c	28.5 a	500.8 a	46.8 b
400 lb N	5.0 b	1.0 c	56.3 d	7.8 d	97.5 c	41.3 a	381.8 a	36.8 b
4 ton PL	6.3 a	2.0 a	72.5 c	39.3 c	135.5 ab	34.0 a	648.3 a	77.5 a
2 ton + 2 ton PL	6.3 a	1.5 abc	73.8 bc	30.0 c	122.3 b	28.0 a	677.8 a	84.5 a
8 ton PL	6.3 a	1.8 ab	83.8 ab	85.8 a	152.5 a	29.0 a	603.5a	97.0 a
4 ton + 4 ton PL	6.2 a	1.5 abc	90.0 a	61.3 b	157.8 a	27.8 a	496.0a	85.8 a

[1]Values within a column followed by the same letter are not significantly different at 0.05 level Waller-Duncan MRT.

Table 4. Analysis of lagoon effluent and fresh water from an associated pond[1].

Sample	N %	P %	K %	Ca %	Mg ppm	Na	SAR
Effluent, Lagoon #2	0.0629	0.007	0.117	0.004	0.000	350	15.2
Freshwater Pond	0.0019	0.000	0.002	0.000	0.000	30	

[1]E.C. of lagoon effluent = 19.1 mmhos.

Table 5. Effect of effluent applied for specific rates of nitrogen on production of ryegrass.

N rate	Ryegrass dry matter yield			
	Harvest 1	Harvest 2	Harvest 3	Total
lb/ac	-----	lb/ac	-----	-----
0	1341	1631 b[1]	1441	4413 b
69	2047	2326 a	1791	6164 a
137	1693	2265 a	1601	5559 a
R^2		0.54	0.91	
C.V.	17.7	4.5	20.7	6.3

[1]Yields within a column followed by similar letters are statistically similar.

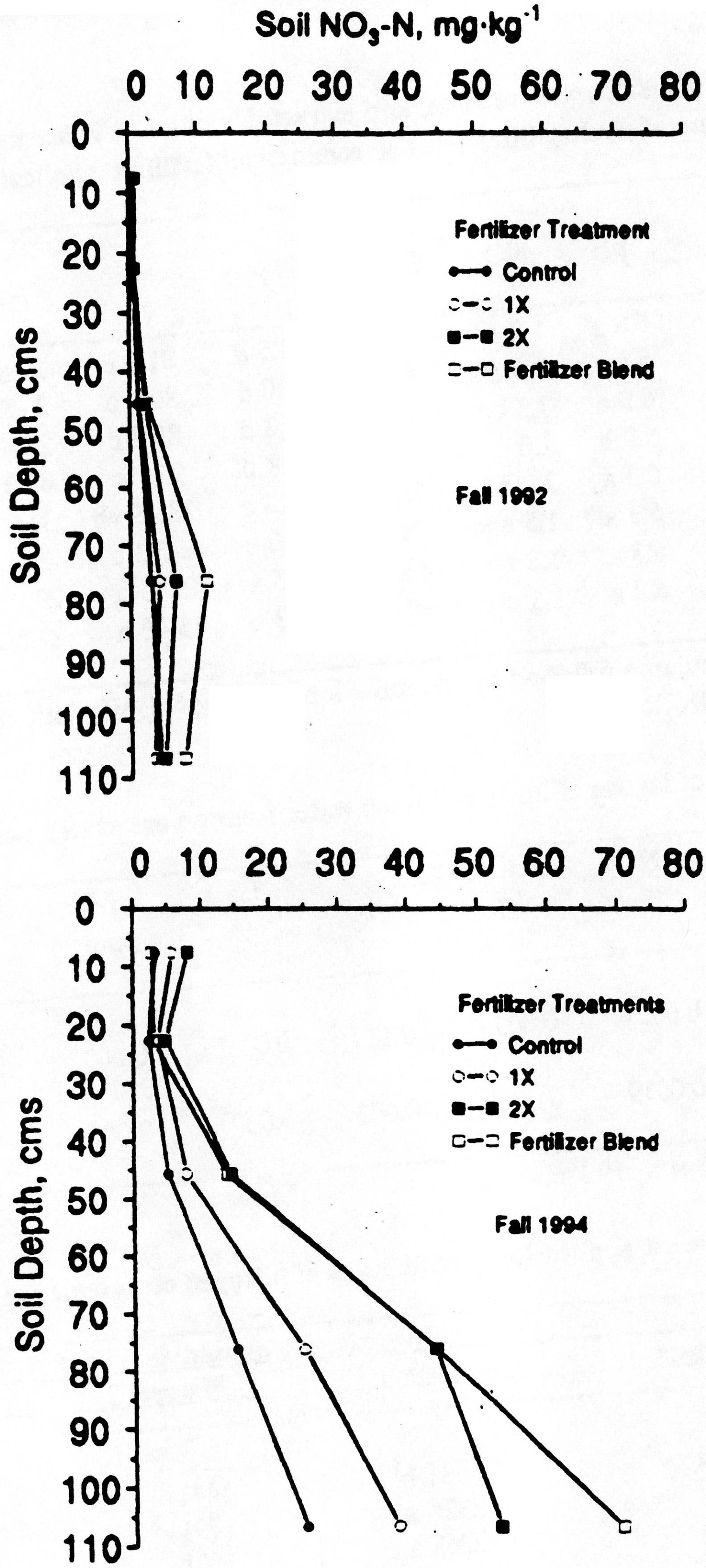

Fig. 1. Comparison of soil concentration of residual N from poultry litter rate and fertilizer blend trearments. Data presented are from the end of a cropping cycle at the beginning and end of a three year study.

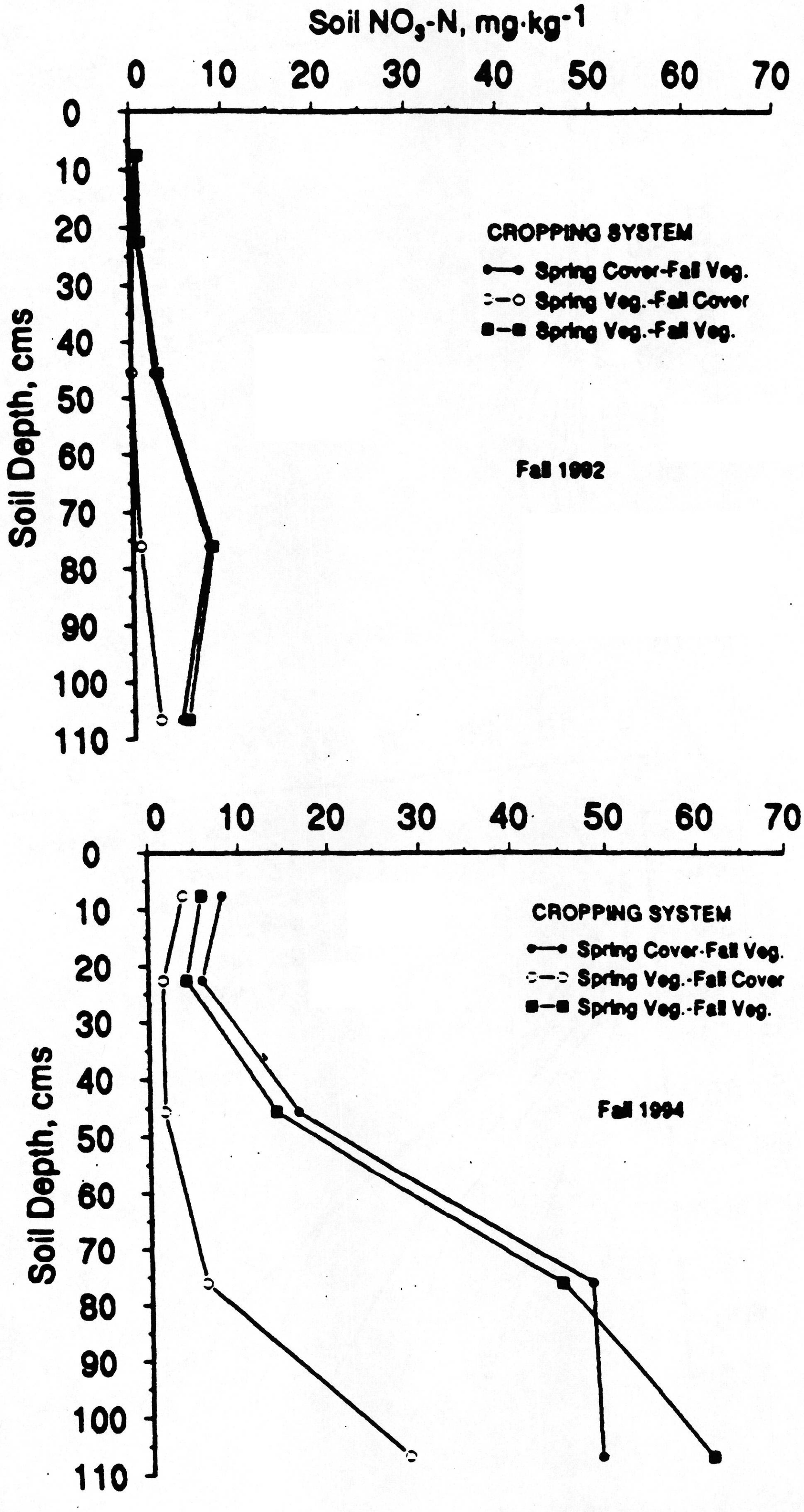

Fig. 2. Comparison of soil concentration of residual N from poultry litter application as influenced by cropping system. Data presented are from the end of a cropping cycle at the begining and end of a three year study.

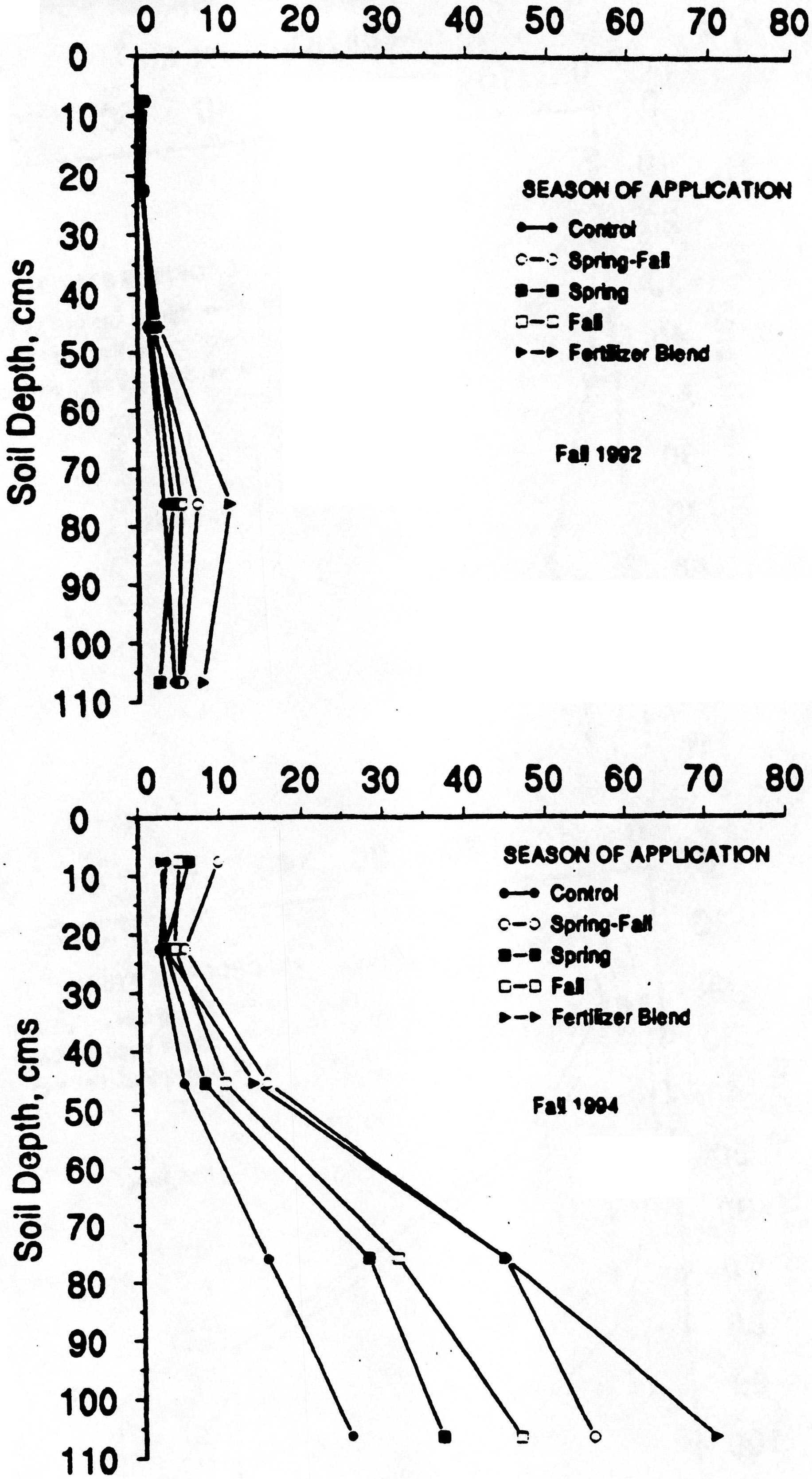

Fig. 3. Comparison of soil concentration of residual N from poultry litter application as influenced by season of application. Data presented are from the end of a cropping cycle at the beginning and end of a three year study.

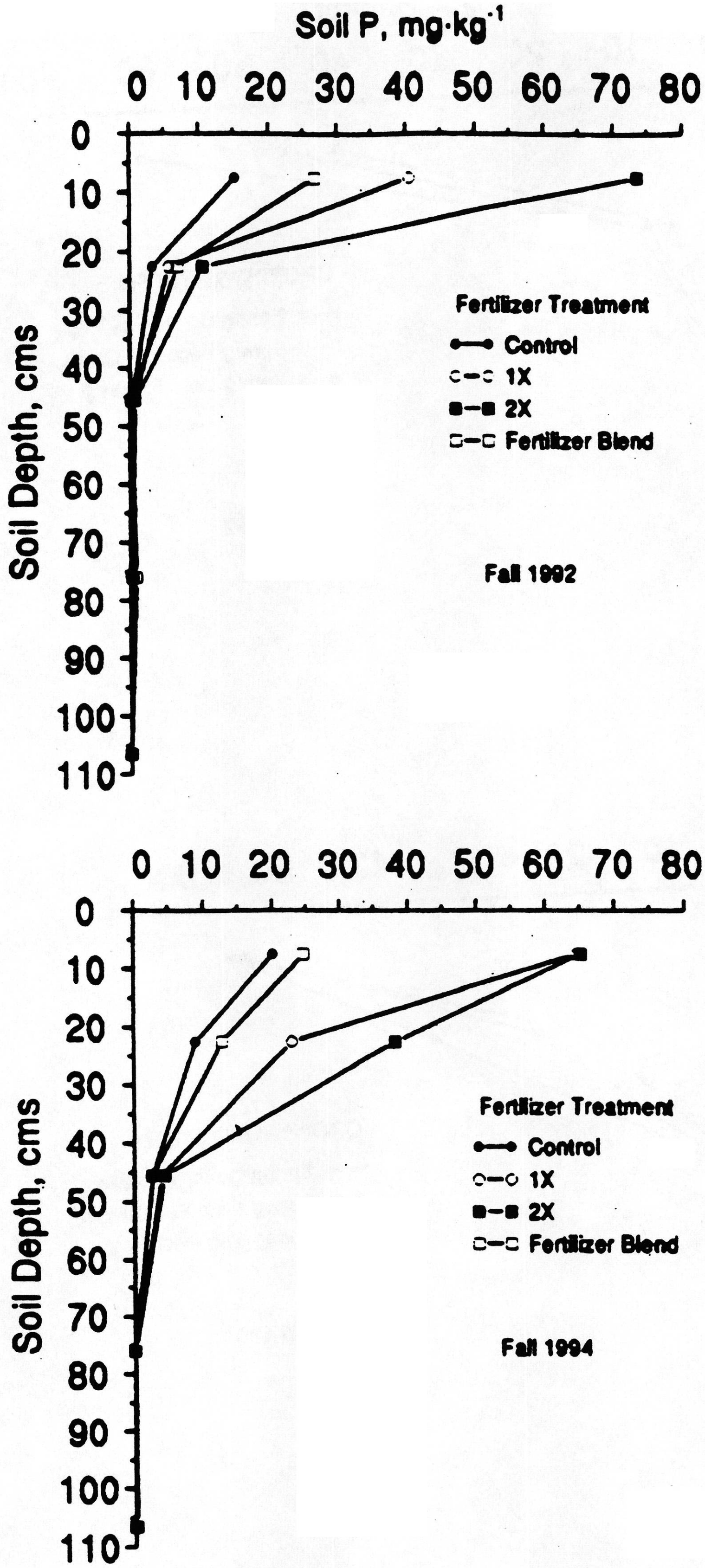

Fig. 4. Comparison of soil concentration of residual P from poultry litter rate and fertilizer blend treatments. Data presented are from the end of a cropping cycle at the beginning and end of a three year study.

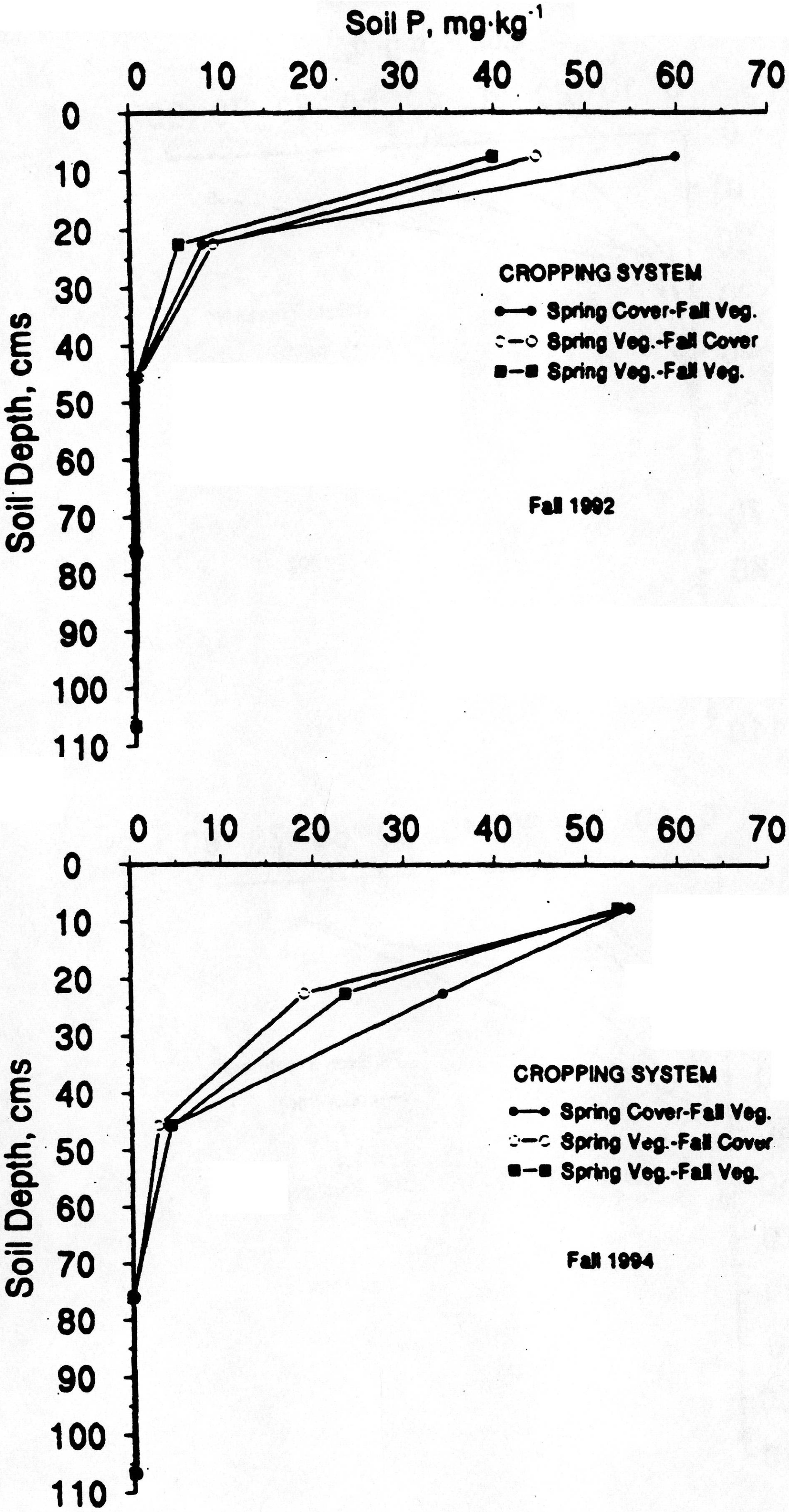

Fig. 5. Comparison of soil concentration of residual P from poultry litter application as influenced by cropping system. Data presented are from the end of a cropping cycle at the beginning and end of a three year study.

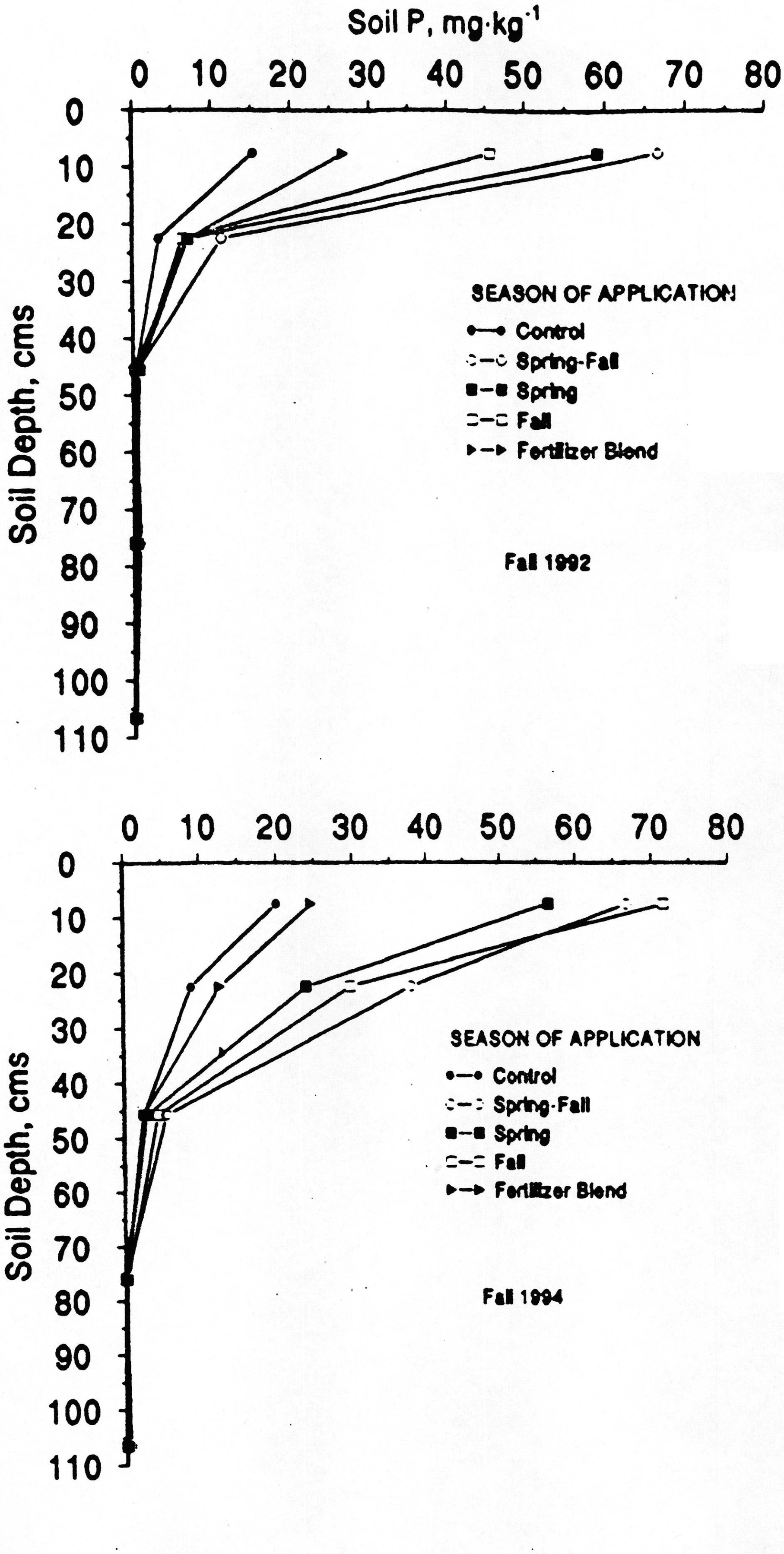

Fig. 6. Comparison of soil concentration of residual P from poultry litter application as influenced by season of application. Data presented are from the end of a cropping cycle at the beginning and end of a three year study.