IRRIGATED MULTIPLE-CROPPING USING BROILER LITTER IN CONSERVATION TILLAGE

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Abstract. A double-cropped, irrigated, conservation-tilled, 3-year rotation was initiated at the Coastal Plain Experiment Station, Tifton, Georgia in 1996 and continues. The objectives are to determine the fertilization needed to balance nutrition supplied as surface-applied broiler litter and to determine the ability to produce high crop yields in conservation tillage. Cotton, peanut, and pearl millet for grain are planted in the summer, and wheat and canola are planted in the winter. Following cotton the plots are fallow. All summer and all winter crops are grown each year. The plots are arranged in split-plots with broiler litter rates of 0, 2, 4, and 6 ton/acre applied on the surface before each crop as the main plots and fluid fertilizer treatments as the split plots. High rates of broiler litter are rapidly increasing soil test P in the surface soil, signaling potential problems in the future. Litter application provided yield and value/acre increases for cotton, grain pearl millet, wheat, and canola. Any litter application was detrimental to peanut yield and grade. At a suggested rate of 2 ton litter/acre, gross returns of cotton increased by $66 or $35 /acre/year due to 10 gal/acre of 10-34-0 or 12-22-5 (2S) as starter fertilizers, respectively, but not consistently to three foliar KNO_3 applications; millet value increased only slightly due to starter application, but by $19 to $28 due to 40 lb N/acre as sidedressed urea ammonium nitrate solution; wheat value increased by $57/acre due to 40 lb N dribbled on 15 February, and canola value increased as much as $84/acre from two dribble applications of 40 lb N as UAN spaced at 45 and 90 days after emergence. Peanut responded only to application of a fungicide (flutolanil) in all 3 years of this rotation. These data should be useful in making recommendations for litter rates and economically efficient applications of fluid fertilizers following litter application in conservation tillage.

INTRODUCTION

Negative effects of water erosion are easy to find in the Coastal Plain of Georgia. Conservation tillage is badly needed. But, adoption of conservation tillage has been slow, mainly due to traditional thoughts of peanut farmers. The belief of those farmers was that the soil must be thoroughly mixed and be fluffy for subsurface development of peanuts and deep-turning with a moldboard plow buries surface debris, helping to reduce the incidence of southern stem rot (white mold) due to the removal of a food source for the soilborne fungal pathogens. Therefore the moldboard plow has been the tillage implement of choice. Since peanut has been the main cash crop and farmers have heavy investments in expensive large tractors and deep tillage implements, tillage for most crops tended to be by the conventional method with the moldboard plow. Recently, tillage experiments have shown that peanut yield and grade is as high in conservation (strip) tillage as for the conventional method (Hook and Thomas, 1998; Gooden, 1998). Nonirrigated strip-till with subsoiling in three consecutive drought years yielded 1642 lb peanut/acre in comparison to 1554 lb for moldboard tillage (Hook and Thomas, 1998). However, net returns were slightly less for the stip-till with subsoiling as the extra costs for weed control exceeded the costs for conventional tillage. Farmers are accepting the strip tillage method due to economics of time and labor. Farmer experience in the short-term has been generally good. However, there remains concern for the practice over the long-term due both to control of perennial weed species and to the supposed inability to get plant nutrients into the root zone when they must be applied on the surface with minimal opportunity for incorporation. Supplying calcium needed for peanut pod development is a special concern in that regard.

The large broiler industry is expanding rapidly and data released in January 1999 indicate that Georgia is the number one producer of broilers in the nation, surpassing Arkansas for the first time in 1998. Previously, the great bulk of broilers were produced in north Georgia. But, nearly all of the current expansion is in the Coastal Plain. Presently, there are approximately 2000 broiler houses in the Coastal Plain and that number could double in the next 5 years. Each broiler house results in approximately 150 tons of litter/year. One important reason for the expansion in south Georgia is that the Coastal Plain has abundant crop land for disposal and utilization of the litter. Such is not the case in north Georgia. Voluminous literature is available to indicate the benefits of nutrients in broiler litter for certain crops, such as corn. But, corn acreage has decreased in the area due to low quality and low profitability. It is apparent that applications of broiler litter will be made on land to be planted to peanuts and cotton, the main cash crops in the Coastal Plain. Benefits on cotton are not expected to be as great as for corn, in fact over application is expected to result in excessive vegetative (rank) growth. Therefore, N-bearing materials, such as poultry litter must be applied with care. Benefits to peanut will be little and the risk of increased disease due to excessive vine growth are expected to be great. In addition, poultry litter does not contain nutrients which will result in a balanced nutritional condition for most crops. Indiscriminate application will lead to serious nutritional imbalances. The flexibility of fluid fertilizer compositions and ease of application make them well poised to be of value in providing balanced nutrition.

Due to increasing demand for cotton and the elimination of the boll weevil, making insect control much less costly, the cotton acreage has expanded very rapidly in the Coastal Plain. Cotton acreage in the region has more than quadrupled in the past 4 years and is currently 1.4 million acres, surpassing the acreage and value of the peanut crop, which has been the crop with the greatest value in the State for many years. Wheat is the greatest value winter crop and is easily double-cropped. Canola and pearl millet, for grain, are promising new crops. At least a 3-year rotation is recommended for peanut and canola to minimize soil-borne diseases.

The goal of the research is to predict supplemental fertilizer needs in a conservation-tilled intensive cropping system receiving variable rates of broiler litter and satisfy those needs with starter-, foliar-, and sidedress-applications of fluid fertilizers.

MATERIALS AND METHODS

An experiment was initiated on the Coastal Plain Experiment Station in Tifton, GA on a Tifton loamy sand, (Plinthic Kandiudult) in Feb. 1996. Former crops were cotton proceeded by wheat. The experiment is a 3-year irrigated double-cropping system with each crop grown each year (Gascho et al., 1997; Gascho and Brenneman, 1998). The sequence of crops in a cycle is cotton, fallow, peanut, canola, pearl millet, and wheat. Within the three cycles grown each year there are four broiler litter rates of 0, 2, 4, and 6 ton/acre as the main plots of a split-plot arrangement of a randomized complete block design. Mean nutrient analysis of the litter is supplied in Table 1.

Within each litter rate, six treatments are included to attempt to balance plant nutrition for top yield, grade and profitability. For the winter crops of canola and wheat, the split-plots are timing and rates of N as surface-dribbled urea ammonium nitrate (UAN, Table 3). For cotton, peanuts, and pearl millet the basic treatments include: 1. nothing additional, 2. 10 gal/acre of 10-34-0 starter, and 3. 10 gal/acre of 8-22-5(2S) starter. Starters are applied 2 inches below and 2 inches to the side of the seed. For cotton, sprays with potassium nitrate during fruit development are applied at first bloom, 2 weeks later and 4 weeks later. The sprays are in 20 gal water/acre at 10 lb KNO_3/acre. For peanut, control for white mold and limb rot are included by either applying or not applying flutolanil (in two applications for each starter fertilizer treatment). Pearl millet plots either receive or do not receive an extra 50 lb/acre N as sidedressed 30-0-0 for each starter fertilizer treatment. There are 4 replications for a total of 288 plots.

The mold board plow was not used in this experiment and surface tillage has been eliminated gradually in the 3 years of the experiment reported. Prior to the summer crops in 1996 the site was chisel-plowed to depth of 10 inches. Litter was incorporated 4 inches deep with herbicide (ethylfluralin at 1 qt./acre for peanut, pendimethalin at 1.5 pt./acre and fluometuron at 1.5 qt./acre for cotton, and propazine at 2 qt./acre for pearl millet) with a rototiller. In the fall of 1996 and 1997 plots to be planted to wheat and canola were subsoiled to 18 inches with three shanks/6 ft. bed. Discing to a depth of 4 inches was also required to incorporate litter and herbicide (trifluralin at 1 pt./acre for canola). In the spring of 1997 and 1998 all plots were paratilled, and all vegetation was killed with glyphosate (1 qt./acre) 2 weeks prior to planting summer crops using strip tillage with subsoiling. At planting, pendimethalin was broadcast (1.5 pints/acre) for peanut. Pendimethalin (1.5 pt./acre) and fluometuron (1.5 qt./acre) were broadcast for cotton and propazine was broadcast (2 qt./acre) for pearl millet. Winter crops planted in 1998 were no-tilled using a Tye planter without using preplant herbicide following paratilling.

Soil samples were obtained in main plots in depth increments of 0-6 , 6-12 , 12-18, 18-24, and 24-30 inches each winter to evaluate changes in nutrient elements with soil depth as affected by litter rate. Only the results for changes of Mehlich-1 P in the top 6 inches are presented here, as changes below the top increment have been minimal to date.

All data were summarized by analysis of variance using the split-plot method. Means for the subplots were separated by LSD at P=0.10.

In this article, we emphasize yield and economic gains from the treatments. For peanut, the value/acre was established by a formula based on yield and grade. For other crops, value is obtained by the mean price of the commodity over the time it was grown in the project. The market price of corn was used to calculate the value of pearl millet grain, since no market is established and the feed value is similar to corn. Value of the change made by fertilizer application was analyzed at the rate of broiler litter currently recommended (not all official at this time) by the University of Georgia Extension Service.

RESULTS AND DISCUSSION

For all crops, except peanut, growth and yield were increased by broiler litter application. In most crops and years, the increased growth was only observed to the 2 or 4 ton rates. Increased peanut growth and development differences were observed to the 2 ton rate in 1996, but not in 1997 or 1998.

Soil test P (Mehlich-1) in the top 6 inches increased in a nearly linear manner over a 2-year period due to broiler litter application rate (Fig. 1). Increases of the magnitude of 32 ppm in 2 years by application of the 6 ton rate (total of 24 ton/acre for the four crops grown during that period) are not acceptable from an environmental standpoint. If high rates of broiler litter are applied, soil P levels will increase to very high levels in a few years, thus defeating one of the prime reasons for locating new broiler houses in the coastal plain of Georgia rather than in the piedmont area, where soil P is already very high by the levels established by the Soil Test Laboratory of the University of Georgia Cooperative Extension Service (Plank, 1986) due to litter application.

For both production and environmental reasons, the Georgia Extension Service is now recommending that litter be applied at 2 ton/acre/crop. Soil test K was depleted for all litter rates, but not to the low level (data not shown). The depletion of soil test K increased slightly as litter rate increased. Broiler litter does not contain adequate K. With time, K will be required to produce good crops, once soil test K is reduced to a low level. Both P and K contents of broiler litter are examples of the need to balance crop nutrition with additional fertilizers where litter is applied.

Analysis of variance by the split-plot randomized complete block method indicates many significant responses in yield for litter application and fluid fertilizer treatments (Table 2). In many analysis, the interaction of broiler litter rate and fluid fertilizer treatment was also significant. The main effects of broiler litter rate are provided in Fig. 2 to 6 for the crops included in the rotation.

Cotton yields were 2 to 2.5 greater than the State average in all 3 years of the experiment (Fig. 2). The main reason for the high yields was irrigation, but broiler litter also had a large positive effect on yield. The effect was positive to the 4 ton rate in 1996 and 1997 and only to the 2 ton rate in 1998. The different response in 1998 was possibly due to the fact that soil N and P levels were increasing to excessive levels by repeat applications of broiler litter. Following application of litter to the 1998 cotton, a total of 20 tons had been applied at the 4 ton rate and 30 tons at the 6 ton rate. These results support the recommendation of only applying 2 ton/acre/crop. Over all litter rates, analysis by LSD at P=0.1 indicate that cotton yields were increased by starter fertilizer applications in 1996 and 1997, but not in 1998. Over all, three foliar applications of KNO_3 did not produce significantly more cotton yield. That result may have been different if soil test K were at a “low” level (0 to 35 mg/kg). For the recommended rate of 2 ton litter/acre gross economic increases were not consistent over the 3 years of cotton in the rotation (Table 4). Mean increases of 66 and $33/acre/year were attained from 10-34-0 and 12-22-5 (2S) starters, respectively. Economic data for the application of foliar KNO_3 at the 2 ton litter rate were variable and inconclusive.

Peanut data are presented as value/acre (Fig.3, Tables 3 and 4). The largest component of value/acre was yield with adjustments due to grade using the USDA Peanut Loan Schedule. In all 3 years, peanut value/acre was reduced greatly by application of broiler litter, regardless of the rate (Fig. 3). That result supports our current recommendation that no fertilizer need be applied to peanuts when soil tests are medium or greater. Consideration is being given to also recommending against the application of any broiler litter for peanut. Peanut has long been known to produce best when residual fertility is supplied (Gascho and Davis, 1994). In none of the 3 years of peanuts did starter fertilizers treatments increase value of peanut when all litter rates were considered (Table 3), but application of flutolanil fungicide in addition to application of normal fungicide for leaf spot provided much increased value. At the proposed recommended rate of broiler litter (none), there appears little justification for farmers to make starter applications for peanut (Table 4).

Pearl millet for grain showed responses to litter to the 6 ton rate in 1996 and to the 2 ton rate in 1997 and 1998 (Fig. 4). Although this crop is not established on many acres at this time, it seems reasonable from the data that a recommended rate would be 2 ton/acre. Over all rates of litter, starter fertilizers did not significantly increase yield, but sidedressing with 50 lb N/acre as UAN did increased yield (Table 3). At a potential recommended rate of litter of 2 ton/acre, 50 lb N/acre provided 19 to $28/acre more gross revenue (Table 4).

Wheat yield was low in 1997 due to late detected disease problems and but higher in 1998. Wheat responded well to broiler litter (Fig. 5) and to sidedressed UAN in 1998 (Tables 3 and 4). Response to litter was to the 4 and 6 ton rates for the two years completed (Fig. 5). Over all litter rates, top dress dribble application of 40 to 60 lb N as UAN on about 15 February (early) produced the greatest yield (Table 3). There appeared to a penalty for late application (15 March) and no additional response to two applications. At the 2 ton litter rate, approximately $60/acre gross revenue was averaged by application of 40-60 lb N early (Table 4).

Canola yields above state averages were produced on the plots in 1997 and 1998. Yields responded positively to litter application, peaking at the 4 ton and 6 ton rates for 1997 and 1998, respectively (Fig. 6). Responses to top dress dribble UAN were also significant, but different than for wheat (Table 3). Late application of the UAN (90 days after emergence(DAE)) resulted in greater response than early application (45 DAE). However, the "early" application on wheat and the "late" application on canola arrived at nearly the same calender date, possibly suggesting that specific weather conditions may have been important in the observed responses. At a 2-ton litter rate, our data suggest profitable responses to dribble applications of UAN on canola. The gross responses averaged $63/acre/year for a single application of 40 lb N at 90 DAE and $84/acre/year when two applications of 40 lb N were made.

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Table 1. Mean nutrient analysis of broiler litter.

Nutrient	Content	Nutrient	Content
	lb/ton		lb/ton
N	48	Fe	4
P_2O_5	46	Al	5
K_2O	34	Mn	0.6
Ca	25	B	0.04
Mg	6	Cu	0.4
		Zn	0.5

Table 2. Analysis of variance for yields†

	Cotton			Peanut			Pearl Millet		
Source	96	97	98	96	97	98	96	97	98
Broiler litter rate	**	*	**	NS	‡	NS	NS	**	**
Fertilizer treatment	NS	NS	NS	**	*	**	‡	NS	*
Interaction	NS	NS	NS	NS	‡	*	NS	**	NS

	Wheat		Canola	
Source	97	98	97	98
Broiler litter rate	**	**	**	**
Fertilizer treatment	**	**	**	**
Interaction	**	**	**	**

† Significance by split-plot method with **, *, ‡, and NS = significant differences at P = 0.01, 0.05, 0.10, or not significant at P = 0.10, respectively.

Table 3. Effects of fertilizer subplots on crop yields and peanut value.

Cotton (lb lint/acre)	1996	1997	1998
No Starter, No KNO_3	1114 b[†]	1120 b	982 a
No Starter, KNO_3	1182 ab	1175 ab	964 a
10-34-0, No KNO_3	1192 a	1228 a	962 a
10-34-0, KNO_3	1204 a	1132 ab	914 a
12-22-5, No KNO_3	1169 ab	1191 ab	994 a
12-22-5, KNO_3	1210 a	1164 ab	1021 a
Peanut value ($/acre)	1996	1997	1998
No Starter, No Moncut	630 c	1028 bc	1300 bc
No Starter, Moncut	1070 a	1072 ab	1578 a
10-34-0, No Moncut	584 c	1023 bc	1355 b
10-34-0, Moncut	887 b	1149 a	1636 a
12-22-5, No Moncut	652 c	971 c	1217 c
12-22-5, Moncut	904 b	1101 ab	1509 a
Pearl millet grain (lb/acre)	1996	1997	1998
No Starter, No Fert. N	2239 c	2736 b	4244 b
No Starter, 50 lb N	2564 a	2927 ab	4286 ab
10-34-0, No Fert. N	2287 abc	2928 ab	3612 c
10-34-0, 50 lb N	2396 ab	3063 a	4385 ab
12-22-5, No Fert. N	2038 c	2940 ab	4009 bc
12-22-5, 50 lb N	2419 ab	3033 ab	4810 a
Wheat (bu/acre)		1997	1998
No Fert. N		18 bc	27 e
40 lb N 3/15		17 cd	36 d
40 lb N 2/15		24 a	42 bc
40 lb N 2/15 + 40 lb N 3/15		18 cd	45 ab
60 lb N 2/15		20 b	45 a
60 lb N 2/15 + 40 lb N 3/15		17 d	41 c
Canola (bu/acre)		1997	1998
No Fert. N		33 c	24 e
40 lb N @ 90 d		38 b	34 bc
40 lb N @ 45 d		35 c	29 d
40 lb N @ 45 d + 40 lb N @ 90 d		39 b	36 ab
60 lb N @ 45 d		39 b	32 c
60 lb N @ 45 d + 40 lb N @ 90 d		42 a	37 a

[†] Values are means of four litter rates and four replications. Values in a crop and column followed by a common letter are not significantly different by LSD at P = 0.10.

Table 4. Increase in yield or gross value due to fluid fertilzer application following two ton broiler litter for cotton, pearl millet, wheat and canola and no litter for peanut.

Cotton	1996	1997	1998	Means	
		------lb lint/acre------			$/acre
No Starter, KNO_3	22	21	0	14	10†
10-34-0, No KNO_3	54	168	69	97	66
10-34-0, KNO_3	149	176	-106	73	50
12-22-5, No KNO_3	58	311	25	131	89
12-22-5, KNO_3	105	171	58	111	75
Peanut value	1996	1997	1998		Means
			------$/acre------		
No Starter, Moncut	469	133	481		361
10-34-0, No Moncut	48	-120	125		18
10-34-0, Moncut	249	220	514		328
12-22-5, No Moncut	47	-24	-171		-49
12-22-5, Moncut	156	6	484		215
Pearl millet grain	1996	1997	1998	Means	
		------lb/acre------			$/acre
No Starter, 50 lb N	384	-99	1195	493	22
10-34-0, No Fert. N	225	-48	-63	38	2
10-34-0, 50 lb N	-71	326	1022	426	19
12-22-5, No Fert. N	82	52	130	88	4
12-22-5, 50 lb N	624	-267	1542	633	28
Wheat		1997	1998	Means	
			------bu/acre------		$/acre
40 lb N 3/15		1	17	9	27
40 lb N 2/15		10	28	19	57
40 lb N 2/15 + 40 lb N		5	30	18	54
60 lb N 2/15		8	32	20	60
60 lb N 2/15 + 40 lb N		4	28	16	48
Canola		1997	1998	Means	
			------bu/acre------		$/acre
40 lb N @ 90 d		6	12	9	63
40 lb N @ 45 d		3	3	3	21
40 lb N @ 45 d + 40 lb		10	13	12	84
60 lb N @ 45 d		6	7	6	42
60 lb N @ 45 d + 40 lb		11	14	12	84

†Means $/acre figured using average prices for the years included: cotton lint =$0.68, Peanut by formula based on yield and grade, pearl millet based on corn @$2.50/bu, wheat @$3.00/bu and canola @$7.00/bu.

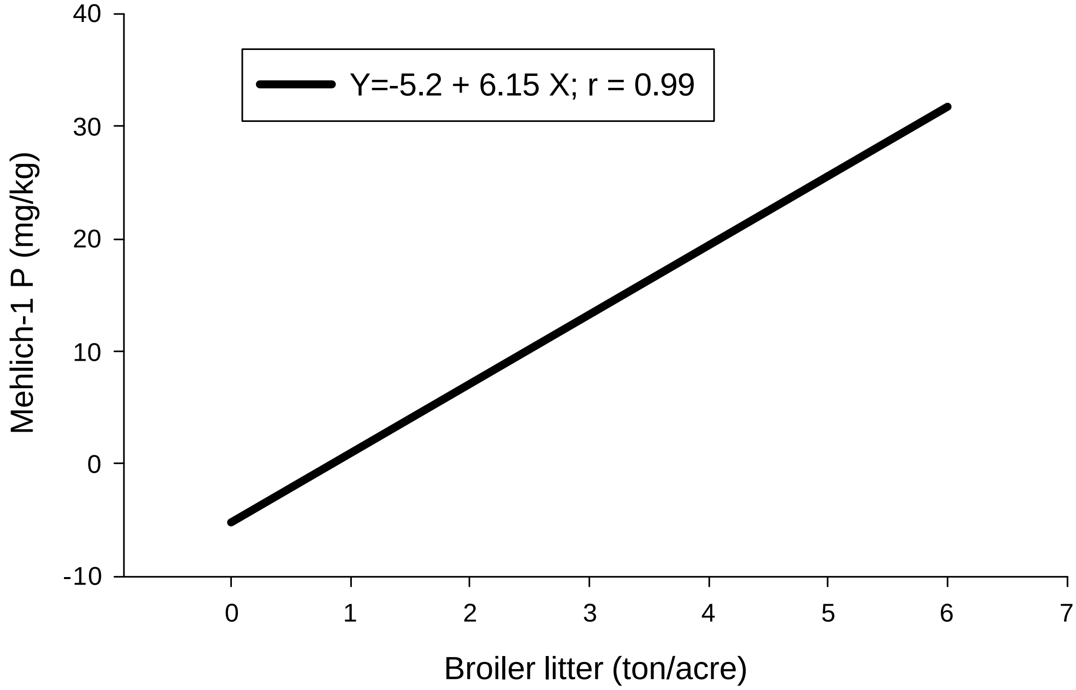

Fig. 1 Mehlich-1 soil P change in top 6 inches due to litter in a 2-year period from 1996 to 1998

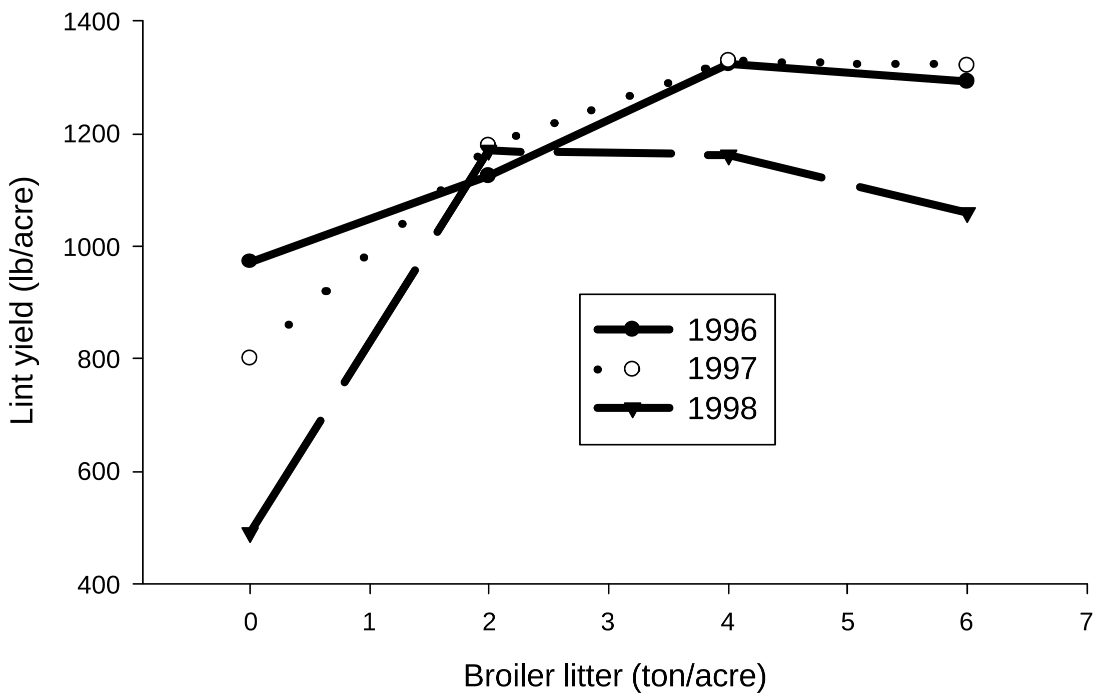

Fig. 2 Broiler litter effect on cotton lint yield, 1996-98

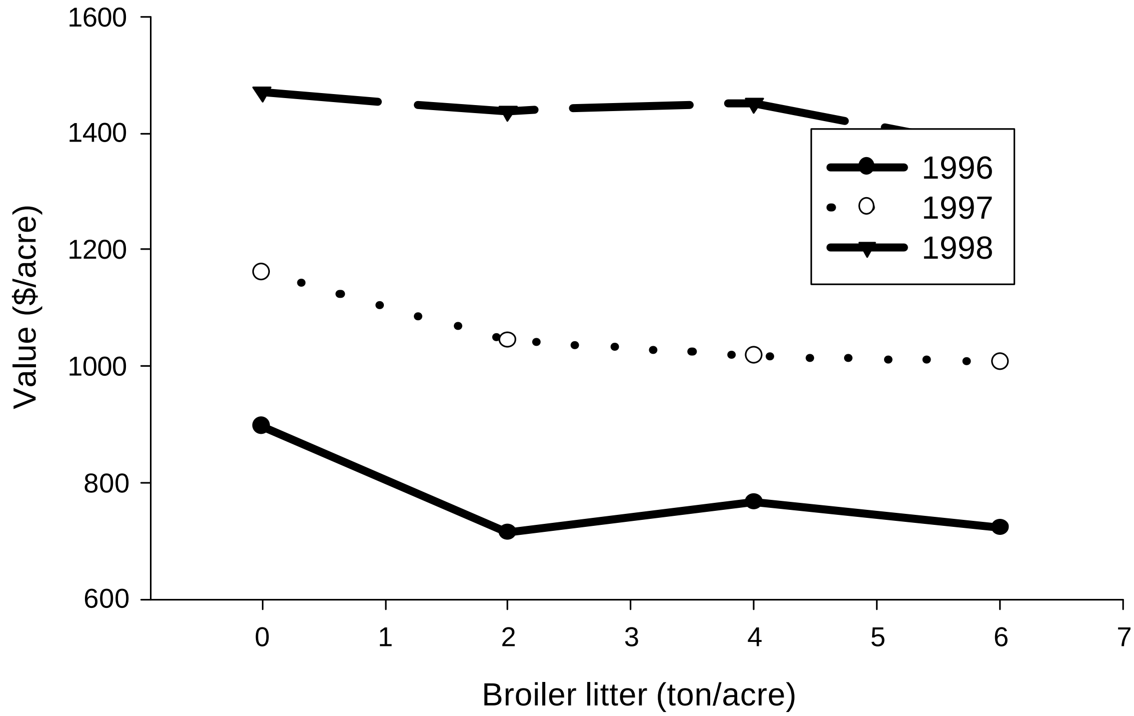

Fig. 3 Broiler litter effect on peanut value, 1996-98

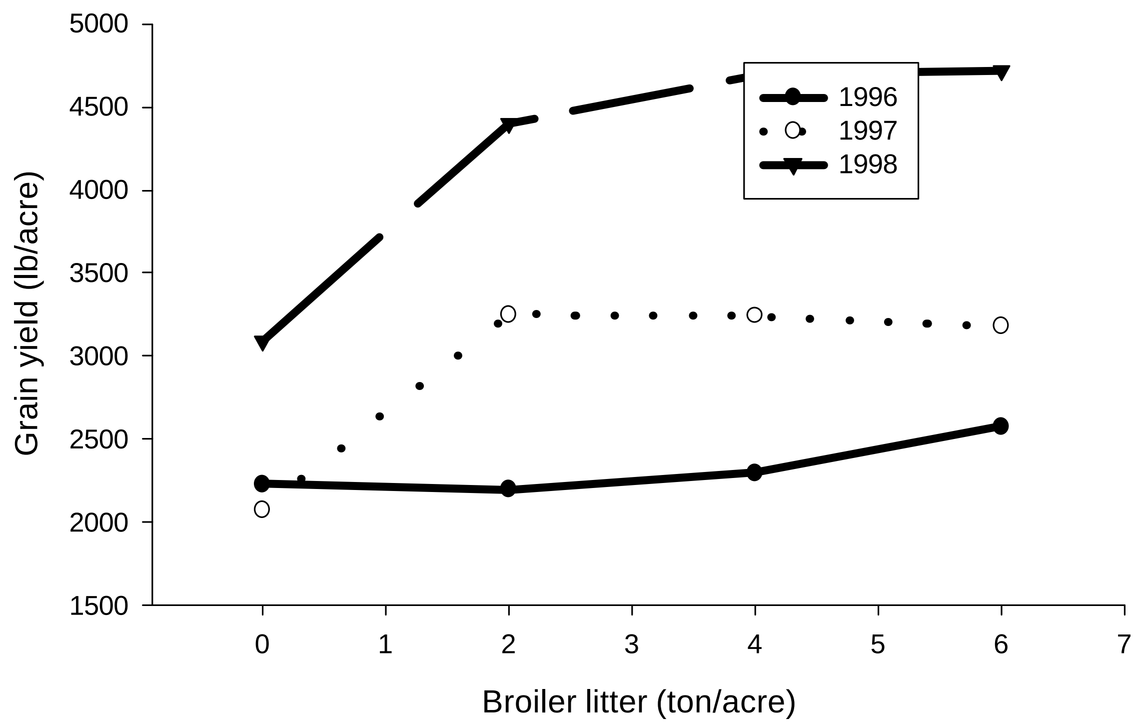

Fig. 4 Broiler litter effect on pearl millet grain yield, 1996-98

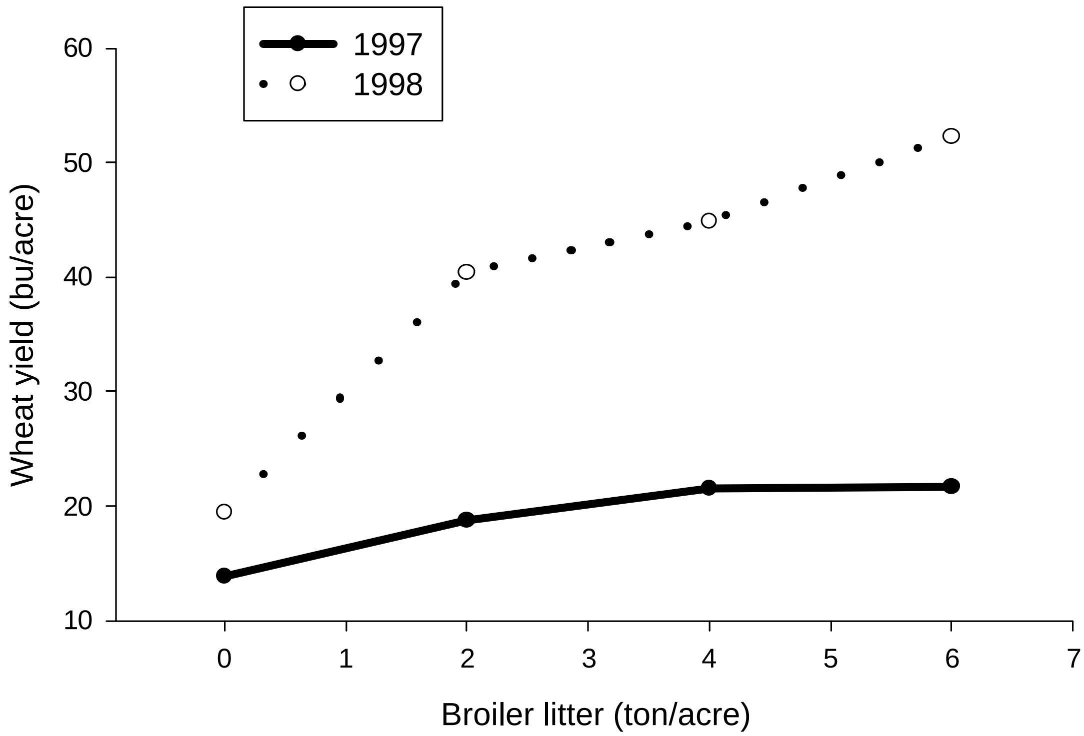

Fig. 5 Broiler litter effect on wheat yield. 1997 and 1998

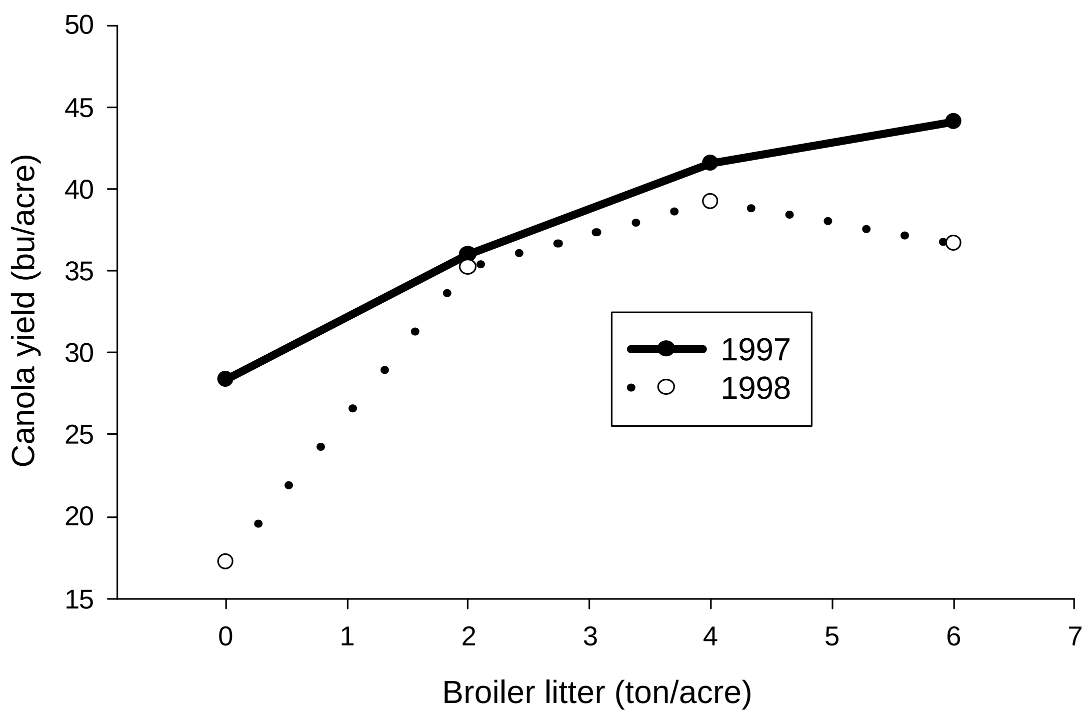

Fig. 6 Broiler litter effect on canola yield, 1997 and 1998