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Pheasant Reproduction and Survival as Related to Agricultural Fertilizer Use

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PHEASANT REPRODUCTION AND SURVIVAL AS RELATED TO AGRICULTURAL FERTILIZER USE

BY

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PHEASANT REPRODUCTION AND SURVIVAL AS RELATED TO

AGRICULTURAL FERTILIZER USE

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor — Date

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PHEASANT REPRODUCTION AND SURVIVAL AS RELATED TO

AGRICULTURAL FERTILIZER USE

Abstract

LAWRENCE FRANCIS FREDRICKSON

Wing-clipped wild pheasants (Phasianus colchicus) were stocked in 1-acre and 0.5-acre pens having oat and bromegrass cover in 1972 and 1973 to test effects of fertilizer (Formulations: 34-0-0, 18-46-0, 0-46-0, and 0-0-60) on pheasant reproduction and survival. One-half of the pens were fertilized with the recommended rate of pelleted fertilizer and the other half without fertilizer. Complete nest searches in July showed that nesting success was not significantly different ($P>0.05$) between treatments for both years. No significant difference ($P>0.05$) was found in clutch size or in number of ovulated follicles from control and experimental hens. Significantly more ($P<0.05$) hens survived in control pens in 1972 because of greater avian predation on experimental hens. In 1973 no significant difference ($P>0.05$) was found between hens surviving for nesting. In both years no significant differences ($P>0.05$) occurred in weight losses of hens between treatments.

Six-week-old game farm pheasants were stocked in 144-square-foot pens to determine survival differences and fertilizer ingestion in 1972 and 1973. Of the 147 birds exposed to fertilizer, only one percent died as a result of fertilizer ingestion. No significant differences ($P>0.05$) were found in weight changes between experimental and control birds. Variable results were obtained from chemistry tests of crop-gastric tracts from killed birds that voluntarily ate fertilizer pellets with feed.

Battery brooder experiments with three-day-old pheasant chicks resulted in 15 percent mortality of 40 chicks as a result of ingestion of pelleted fertilizer. No significant difference ($P>0.05$) occurred in weight changes between treatment groups.

In 1972 and 1973 hen pheasants were given single weekly capsules containing 0, 100 mg, 300 mg, and 900 mg of a fertilizer mixture. No significant difference ($P>0.05$) occurred in either year for egg production between treatment groups. For the two years only eight percent of the experimental hens died from fertilizer. No significant differences ($P>0.05$) occurred in weight changes between treatment groups for 1972 and 1973. There were no significant differences ($P>0.05$) between treatment groups in egg fertility, hatchability, pipping rates, eggshell thickness, crippling of chicks, visual cliff chick behavior, response of chicks to hand catching, and survival and weights of chicks at six weeks of age.

It was concluded that fertilizer does not affect reproduction of wild pheasants in agricultural areas of South Dakota. However, some mortality' probably occurs from ingestion of fertilizer by both chicks and adult birds.

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Tom LeFaive, wildlife student, was hired to assist with some of the work in 1972 and did excellent work. Several other wildlife

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The Farmers Cooperative Company at Brookings supplied small portions of fertilizer for some of the experiments. All of the fertilizer was obtained from this source.

A study of this magnitude requires the help and encouragement of many experts and friendly helpers in many departments, within and without the University. I am indebted for this help. An essential to the study, but in a different way, has been the support of my family and my wife, Janice, for which I am grateful.

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INTRODUCTION

Approximately 225 thousand tons of pelleted fertilizers are used in South Dakota annually (Department of Agriculture 1972, 1973) with much of it used in the main pheasant range. Pheasants are the most important upland game bird in South Dakota and evidence exists that pheasants consume this material and that it may affect them.

The objectives of this study were (1) to determine if nesting hens would consume enough pelleted fertilizer to significantly reduce nesting success, (2) to monitor the survival. of pheasants that ate fertilizer, and (3) to study effects of fertilizer force-fed to pheasants.

REVIEW OF LITERATURE

The use of fertilizers as well as insecticides and herbicides has been suggested as one of the causes of the general decline in upland game populations in the United States and abroad. However, little can be found in the literature about effects of fertilizer on wild animals. The only verified report of birds killed in South Dakota was by Conservation Officer Leroy Sorenson (Tyndall, S. D. Dept. of Game, Fish and Parks). He was called to the John Kreeber farm south of Tabor on June 3, 1972 to investigate a report of dead and dying birds found in a field the previous day. John Kreeber said he did not see any dead pheasants but he observed one hen that appeared to be in distress. Sorenson found two dead Franklin Gulls (Larus pipixcan) and one dead Brown Thrasher (Toxostoma rufum) in one field and observed that surface blood vessels appeared burst. Corn had been planted in part of the field on June 1 with pelleted ammonium nitrate fertilizer applied at the same time. The planter was set incorrectly and a large portion of the fertilizer was left exposed on the surface of the soil. No rain occurred during these two days.

Pheasants are suspected of consuming fertilizer pellets because of their mineral value, or salty flavor, or because they resemble grit or weed seeds. Hens may be particularly vulnerable during the egg-laying period since they require about four times the normal amount of calcium and other minerals in this period and have the ability to select out calcium-containing materials (Sadler 1961). Many fertilizer formulations contain calcium which seems the most likely reason for birds to eat the material.

The most dramatic, large-scale known mortality of pheasants caused by fertilizer occurred at the Waterloo Wildlife Experiment Station in Ohio (Sickles and Goldstein 1957). There, pheasant-rearing fields were heavily treated in April with 12-12-12 granulated fertilizer at the rate of 400 pounds per acre. After fertilizing and planting, total rainfall was 7.60 inches for the next 10 weeks (about half of normal rainfall) prior to the release of 1000 six-week-old pheasant chicks on July 16. All chicks were dead by July 30. Laboratory examination showed slight hemorrhages in the muscles of the breast and thighs. When other groups of birds which had been placed in these pens were taken out, mortality ceased. It became apparent that the birds were dying when they were exposed to the soil in their pens. The birds would dust in the soil and pick up the undissolved granules of fertilizer. Reeves pheasants (Syrmaticus reevesi) and white rock chickens (Gallus domesticus) were not affected. Reeves pheasants were observed to do very little picking in the soil and spent most of their time walking along the fences. After several additional experiments were concluded, involving exposure of pheasants'to these fertilized fields or to fertilizer sprinkled over their feed, the total loss was nearly 4500 birds. Contents from crops of affected birds were positive to tests for nitrates. The final report from Reynoldsburg Diagnostic Service Laboratories included this statement: "From the history of the case as well as our laboratory findings, it would appear to us that nitrates played a major role in the pheasant population losses at the Waterloo Station during the past summer."

In view of the evidence that was gradually accumulating that pheasants could die from fertilizer, it became of interest to know how small

an amount of this material would kill an adult bird. Trautman (1966) force-fed ammonium nitrate fertilizer (33 1/3-0-0) in capsules to nine adult pen-reared cocks. Six of the birds fed two or more grams of this material died. One very heavy bird (62 ounces) that was fed two grams and two birds fed less than two grams showed no ill effects. This experiment demonstrated that ammonium nitrate fertilizer could have a lethal effect on pheasants. Auuiionia is toxic and could be absorbed into the blood stream and cause destruction of blood cells or have other detrimental effects.

Feldt (1966 and 1967) exposed cocks to ammonium nitrate fertilizer and cocks and hens to phosphate fertilizer in Indiana. Game farm birds were used in penned and simulated field experiments. He concluded that fertilizer has very little or no effect on wild pheasant populations because his study birds consumed very little and what they did eat had no effect on them.

Two years of research were conducted with fertilizer before 1972 by the South Dakota Department of Game, Fish and Parks (Fredrickson and Trautman 1971, and Fredrickson 1972, 1973). Five experimental and five control pens each 144 square feet in size were stocked with one to two hens and one cock in early April in these experiments. Pelleted fertilizer (12-12-12) was applied on brome and oats in experimental pens starting in early April. Physical effects on pheasants and their reproduction were monitored and other data were collected.

Results from the first year's (1969-70) experiments showed that fertilizer pellets were consumed by pheasant hens during the egg—laying period (Fredrickson and Trautman 1971). Egg production was more than

twice as high from the seven hens in the five fertilized (experimental) pens as from the seven hens in the five control (unfertilized) pens. Two of the nests in the experimental pens were incubated but for only very short periods (embryos in each clutch were at the two-day developmental stage when abandoned). Three nests were incubated in the control pens of which one was hatched. Embryos of the other two egg clutches were at the 19-day and 10-day developmental stages, respectively, when abandoned. Intensity of broodiness appeared considerably stronger in the control pens. No other differences were noted between experimental and control birds regarding behavior, incidence of mortality, eggshell thickness, and in embryo development among eggs when artificially incubated. Eight eggs showed negative results when tested for occurrence of nitrates (Fredrickson and Trautman 1971).

Results from the second year (Fredrickson 1973) experiments confirmed that fertilizer pellets were consumed by pheasant hens during the egg-laying period. No significant differences were detected between experimental and control birds regarding behavior, incidence of mortality, eggshell thickness, and in embryo development among eggs when artificially incubated. Reliability of experimental results regarding egg production, broodiness, and brood production in the second year was reduced because of the excessive human or animal aggravated disturbance which caused injuries to breeding hens. Seven chicks from eggs taken from fertilized pens were cripples when hatched (32 percent of all chicks hatched from fertilized pens). All chicks from control pen eggs were normal.

MATERIALS AND METHODS

All fertilizer formulations were obtained from the Farmers Cooperative Company, Brookings, South Dakota.

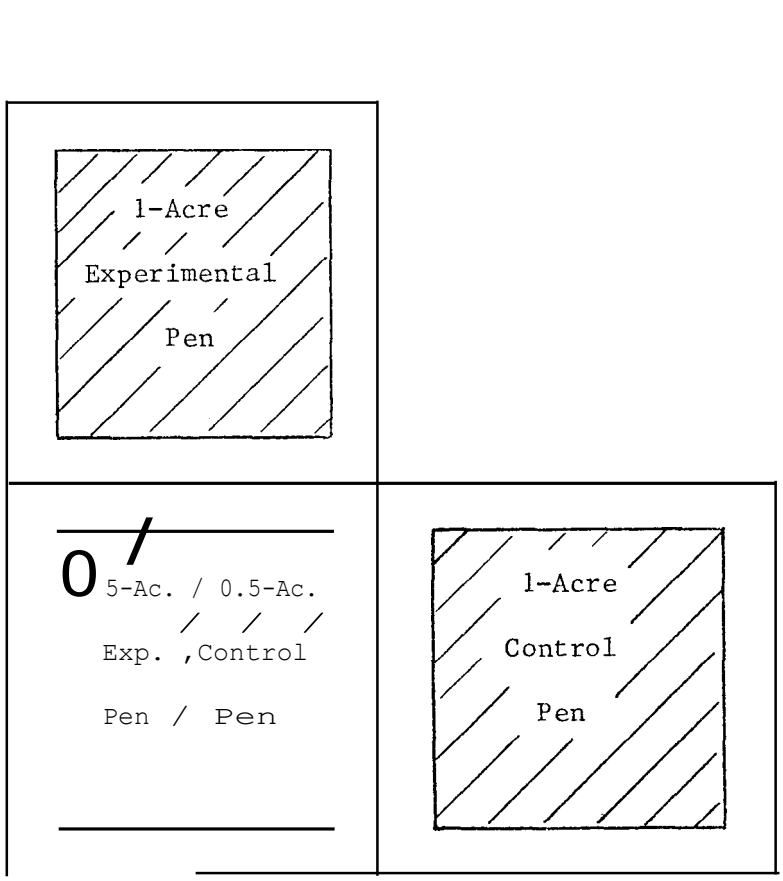
Experiments in 1-Acre and 0.5-Acre Pens

In 1972, three one-acre pens with bromegrass and oats were used to study the effects of voluntarily ingested fertilizer on pheasants and pheasant reproduction (Fig. 1). One pen was a control (not fertilized), the second an experimental (fertilized) and the third was divided into two 0.5-acre pens (one being a control and the other an experimental pen). Eight, 0.5-acre pens were used at the same location in 1973. Four of these pens were experimental and four were control (Fig. 2). The experimental treatment was randomly assigned to half of the pens. All pens were surrounded by an eight-foot fence.

Fertilizers were applied in these pens at rates recommended by the Plant Science Department at South Dakota State University for crops in Brookings County, assuming medium-high organic matter, low phosphorus, and medium potassium. The annual fertilizer application was as follows:

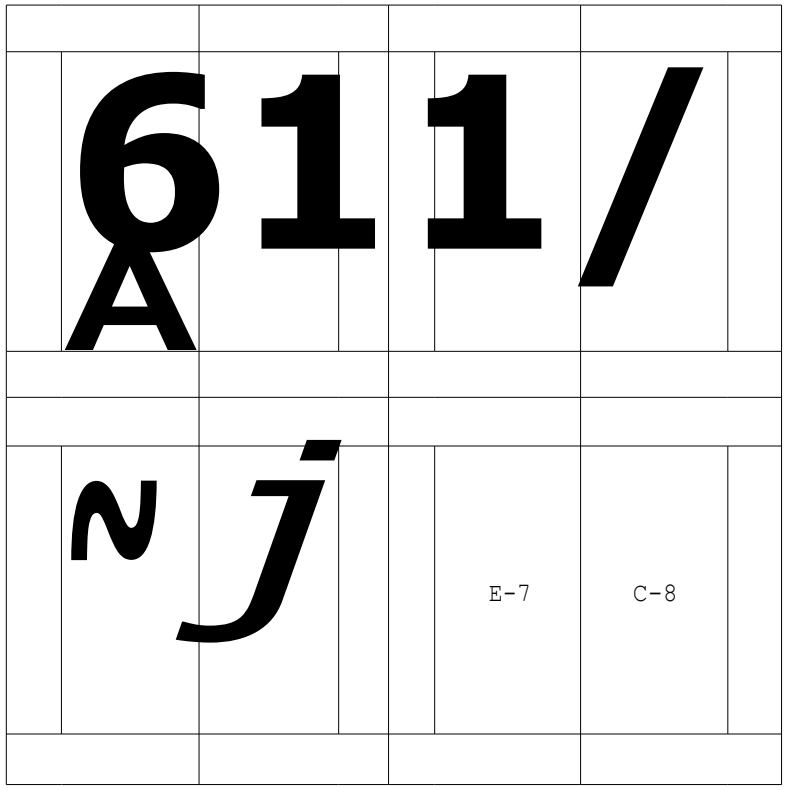
Crop	Recommended lb. Fertilizer/Acre N + P209 + K20			Pounds of Fertilizer to Apply Per Acre 34-0-0	18-46-0	0-46-0	0-0-60
Oats	45	45	15	106	50	50	25
Brome	100	20	45	282	22	22	75

Previously plowed and disked ground was broadcast planted with oats by hand on April 20, 1972. Fertilizer was broadcast with a Cyclone hand seeder over the oat seed before the area was disked. The



Legend: Oats Cover Brome Border Cover (18 Ft. Wide)

Fig. 1. Arrangement of 1-acre and 0.5-acre pens, South Dakota fertilizer study, 1972.



Legend: Oats Cover Brome Border Cover (18 Ft. Wide)

E=Experimental C=Control

Fig. 2. Arrangement of 0.5-acre pens, South Dakota fertilizer study, 1973.

north one-third of both the oats field and the brome border were then broadcast fertilized. Birds were stocked in the pens on May 29. One-fourth of the recommended rate of fertilizer for the oats was distributed over the whole field with the oat seed and then disked. The other three-fourths of the fertilizer was applied in three applications on the surface; the north one-third of the oats and brome fertilized on April 20, the middle one-third on May 15, and the south one-third on June 1. The last two fertilizations were each made when about 90 percent of the previously applied pellets disappeared. This procedure was to simulate a situation where several fields are fertilized at different times and available to moving birds. It also insured that fertilizer was available to birds on the experimental plots at all times and that applications were not in excess of recommendations on any area. An equal weight of sand was applied in experimental and control pens at the time of fertilization to equalize disturbance factor of fertilization.

The same procedure was followed in 1973 but initial fertilization was on April 13 (portion disked with seed), and on May 2 (portion on ground surface) when the"birds were stocked in the pens. The pens were refertilized on May 17 and May 30.

In 1972 wild pheasants were obtained in the spring and in 1973 wild pheasants were caught in the fall and spring. The pheasants were banded, wing-clipped, stratified by weight, and randomly assigned to pens on April 29, 1972, and on May 2, 1973. The stocking rate was twenty hens and two cocks in one-acre pens and ten hens and one cock in 0.5-acre pens. Water for the birds was placed in each pen.

Two complete nest searches were conducted each year in July to determine the effects of voluntarily-ingested fertilizer upon reproduction. All nests were recorded, dated,-and plotted on a grid. Other information recorded included number of eggs (with hatched, active, abandoned or destroyed status), stage of incubation (determined by aging the embryo in one or more eggs as described by Labisky and Opsahl 1958), and cover type (oats or brome). A small gasoline-powered sickle-bar mower was used to cut the oats before the final nest search.

All hens remaining in the pens after the final nest search were collected and weighed. Ovaries were removed and preserved in formalin-ethyl alcohol-acetic acid and later examined for ovulated follicles (Meyer et al. 1947; Kabat et al. 1948; Buss et al. 1951; and Allen 1969).

Soil samples were taken with a standard core sampler to a depth of six inches. Cover in each pen consisted of two-thirds oats and one-third bromegrass. Nine subsamples were taken in the oat portion and mixed for one sample and eight subsamples were taken in the bromegra.ss portion and mixed for one sample for each 0.5 acre. Samples were taker, before (April) and after the experiment (August) each year.

Dead birds were submitted to the Animal Disease Diagnostic Laboratory at South Dakota State University for necropsy and bacteriological examination. For some birds they also examined the digestive tracts from the mouth through the posterior proventriculus for fertilizer material and tested washings from crop, esophagus anad proventriculus for ammonia and elevated levels of potassium.

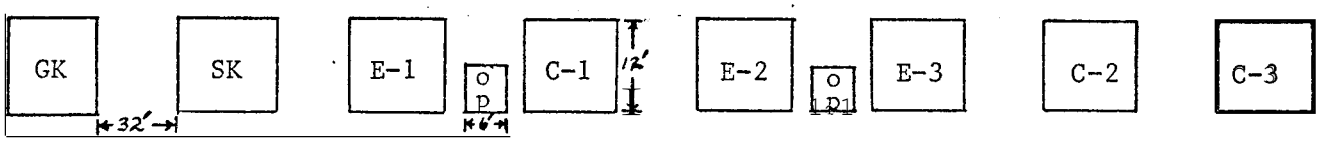
Feed consisted of a mixture of one-third shelled corn and two-thirds scratch grain (flax screenings). Scratch grain contained several types of weed seeds as well as assorted grains. This was scattered in the pens about every three days as it was eaten.

The study was conducted at the South Dakota State University Wildlife Research Area (one mile north of Brookings) in Brookings County. Daily precipitation and maximum and minimum temperatures records were obtained from the Agricultural Engineering Weather Station, South Dakota State University, located about three-fourths mile southeast of the study area.

Experiments in 12 Foot by 12 Foot Pens

Six, 144-square-foot pens were used to study the effects of voluntarily ingested fertilizer on six-week-old pheasants. Additional birds were exposed to fertilizer in two, 144-square-foot pens and then killed so the crop-gastric tracts could be tested to determine ammonium and potassium levels in birds that had ingested fertilizer (Fig. 3).

Cover in the 12 foot by 12 foot pens consisted of one-half bromegrass and one-half spring-planted oats. The recommended fertilizer formulation for the oat portion was hand-broadcast in the three experimental pens at the rate of 400 pounds per acre prior to disking. Subsequent fertilizer applications were a mixture of the four formulations most frequently used in South Dakota and mixed in approximate proportions to the quantity of each sold in the state (18-46-0, 34-0-0, 0-46-0, and 0-0-60 in a respective ratio of 4:4:1:1). Each application was 400 pounds per acre and was scattered uniformly over all the oat portion and one-



GK = Grower Feed Kill Pen

SK = Scratch Grain Feed Kill Pen

E = Experimental Pens

C = Control

OP = Outside Fertilizer Pellet Control Plots

Fig. 3. Arrangement of 12 foot by 12 foot pens, South Dakota fertilizer study, 1972-73.

half of the brome portion when 90 percent of the previous application was gone. This procedure kept some fertilizer available to the birds throughout the experiment.

To determine the physical effect of voluntarily-ingested fertilizer on six-week-old pheasants, pinioned. chicks hatched from game farm hens were placed in six of the pens (three control and three experimental) for one week periods. Different groups of birds were used in each replication and they were weighed to the nearest gram before and after each replication. Ten chicks were stocked in each pen in 1972 (four replications) and nine in each pen (one replication) in 1973. Feed consisted of commercial pheasant grower scattered uniformly on the ground. Water was also provided.

For sampling the rate of pellet disappearance in the pens, a one-square-foot plot was established in all experimental pens in the oat cover. Two control plots were also placed outside the pens in oat cover. One hundred pellets (40 of 18-46-0, 40 of 34-0-0, 10 of. 0-46-0, and 10 of 0-0-60) were hand placed on all plots and daily counts made of pellets remaining. Pellets were usually replaced daily on these plots or at least when 90 percent of the previous pen application was gone. All old pellets were removed from the one-square-foot plots before refertilization.

Additional six-week-old game farm chicks were placed in two of the pens at the rate of four chicks per pen. These were killed daily after exposure to fertilizer to ascertain whether pellet material was ingested and, if so, to document physical and chemical criteria for field and laboratory diagnostic purposes. Feed in one pen was a diet of high protein chick feed placed in one location. Feed used in the other pen was

scratch grain (flax screenings) hand-scattered in the pen. Two birds from each pen were killed in late afternoon on each of two days. The digestive system from mouth to the posterior proventriculus was removed and washed with 2.5 milliliters of distilled water. These washings were used in testing for ammonia and elevated potassium levels. Examination of dead birds and work location were the same as described previously.

Experiments in Battery Brooders

To determine voluntary ingestion of fertilizer and effect of fertilizer on three-day-old pheasant chicks, chicks hatched from game-farm hens were placed in two standard battery brooders (one was control and one experimental) at the rate of 10 chicks per brooder. The wire floors of the brooders were covered with a cardboard panel that fit tightly and had two-inch high sides to retain fertilizer and feed. A weighed amount or counted number of pellets at the 4:4:1:1 ratio were scattered on the brooder floor with commercial feed. Water was provided. Remaining pellets were removed and counted daily in some cases and weighed after a few days in other instances. Chicks were kept in battery brooders for seven days per replication. Chicks were weighed to the nearest gram before and after each replication.

Force-Feeding Experiments

Game-farm pheasants were caged inside a building with controlled temperature and light. Chicks were hatched in a forced-draft incubator maintained by the Poultry Research Center, and then brooded in battery-type brooders. They were placed in outside pens when six weeks old for hand-catching experiments.

Gelatin capsules were filled with a mixture of the four fertilizer formulations most frequently used in South Dakota in approximate proportions to their sales (18-46-0, 34-0-0, 0-46-0, and 0-0-60) in a respective ratio of 4:4:1:1. Capsules were weighed individually in milligrams with an accuracy of +2.5 percent of the fertilizer material.

Three experimental groups of six birds each were fed capsules of the fertilizer mixture at dosages of 100 milligrams, 300 milligrams, and 900 milligrams. The six birds in the control group were fed empty capsules. Capsules were inserted into the esophagus via a glass tube.

The hens and five cocks were caged individually in late January and subjected to 16 hours of light daily to stimulate breeding. Individual hens were successively mated to the pool of cocks starting in late February.

Eggs were gathered beginning in early March and placed in the incubator weekly for 15 weeks. Daily records were kept on number of eggs laid, fertility (number of eggs with at least one to two days of embryo development) and hatchability (number of fertile eggs hatched). Records were also kept on the number of chicks that had difficulty standing on one or both legs (crippled) and all embryos were examined for abnormalities.

Eggshells were measured with an Ames thickness micrometer to 1/100 millimeter. The average thickness value for each eggshell was determined from three thickness measurements taken around the widest part (transverse section) of the egg. Inside surfaces of shells were rinsed with water to remove excess yolk and albumin. Hatched eggshells were measured without membranes.

Behavior was tested on a visual cliff, a Baxter et al. (1969) modification of one used by Tallarico and Farrell (1964).

Chicks were held in brooders and records were kept on survival until six weeks old.

Chicks surviving to six weeks were moved outside to 16 foot by 16 foot pens and tested for wildness by hand catching as described by Dahlgren et al. (1970).

RESULTS AND DISCUSSION

Experiments in 1--Acre and 0.5-Acre Pens

Nesting and Reproductive Performance

The number of successful nests (hatched and active combined per nesting hen) was not significantly different (P>0.05) in control (0.64) and experimental (0.64) pens by Chi-square analysis in 1972 (Table 1). The number of successful nests (hatched and active nests combined per nesting hen) in 1973 was 0.51 for control and 0.54 for experimental hens and also not significantly different (P>0.05) by Chi-square analysis.

The number of eggs laid per nesting hen was similar for control hens (18.46) and for experimental hens (17.43) and not significantly different (P>0.05) by Chi-square analysis in 1972 (Table 2). The number of eggs per nesting hen was higher for control hens (16.82) than for experimental hens (12.40) but not significantly different (P>0.05) by Chi-square analysis in 1973. No significant difference (P>0.05) was found between clutch size in nests of control hens (average of 11.4 eggs) and in nests of experimental hens (average of 9.5 eggs) for 1972 using analysis of variance (Table 3). Similarly, no significant difference (P>0.05) was found between control hen clutch size (average of 9.50) and in experimental hen clutch size (average of 9.40) for 1973.

For 1972 there was no significant difference (P>0.05) between the number of ovulated follicles from control hens (average of 33 + 14.07 standard deviation, 43 percent coefficient of variation) and from experimental hens (average of 31 + 13.23 standard deviation, 43 percent coefficient of variation) using analysis of variance (Table 4). In 1973

Table 1. Pheasant nests found in 1-acre and 0.5-acre pens, South Dakota fertilizer study, 1972-73.

Pens[a]	Number of Nests			Successful Nests per Nesting Hen
	Successful	Unsuccessful	Total	
		1972		
Control (22)	14	19	33	0.64
Experimental (14)	9	14	23	0.64
		1973		
Control (39)	20	37	57	0.51
Experimental (35)	19	19	38	0.54

[a]Number of nesting hens in parentheses.

Table 2. Number of eggs in 1-acre and 0.5-acre pens, South Dakota fertilizer study, 1972-73.

Pens[a]	Number of Eggs			
	In Nests	Scattered	Total	Per Nesting Hen
			1972	
Control (22)	376	30	406	18.5
Experimental (14)	218	26	244	17.4
			1973	
Control (39)	542	114	656	16.8
Experimental (35)	358	76	434	12.4

[a]Number of nesting hens in parentheses.

Table 3. Clutch size in 1-acre and 0.5-acre pens, South Dakota fertilizer study, 1972-73.

Pens	Clutch Size[b] ± SD Unsuccessful[a]	Successful[c]	All Nests
		1972	
Control	9.6 ± 6.8 (19)	13.8 ± 5.2 (14)	11.4 ± 6.4 (33)
Experimental	6.6 ± 5.1 (14)	14.0 ± 3.2 (9)	9.5 ± 5.7 (23)
		1973	
Control	8.7 ± 4.7 (37)	11.1 ± 4.5 (20)	9.5 ± 4.7 (57)
Experimental	7.5 ± 3.8 (19)	11.4 ± 3.8 (19)	9.4 ± 4.2 (38)

'Abandoned and destroyed combined.
[b]Number of nests in parentheses.
[c]Hatched and active combined.

Table 4. Number of ovulated follicles from hen pheasants in 1-acre and 0.5-acre pens, South Dakota fertilizer study, 1972-73.

Pens	Number of Hens	Avg. Number Per Hen ± SD	Coefficients of Variation
		1972	
Control	22	33.0 ± 14.07	43 percent
Experimental	13	30.6 ± 13.23	43 percent
		1973	
Control	35	32.9 ± 20.94	64 percent
Experimental	30	33.6 ± 17.89	53 percent

there was again no significant difference ($P>0.05$) between the number of ovulated follicles from control hens (average of 33 + 20.94 standard deviation, 64 percent coefficient of variation) and from experimental hens (average of 34 + 17.89 standard deviation, 53 percent coefficient of variation) using analysis of variance.

In 1972, combining all nest categories, 79 percent of the nests were located in the brome cover border while 21 percent were in oat cover (Table 5). When considering only active and hatched nests, 78 percent of the nests were located in brome cover and 22 percent in oat cover. Using Chi-square analysis, no significant differences ($P>0.05$) were found between control and experimental treatments for location of nests in these two cover types for all categories of nests combined; however, a significant difference ($P<0.05$) was found between control and experimental treatments for location in cover types when only active and hatched nests were considered (Table 5). The latter difference is thought to be meaningless because of the small sample size obtained by separating out these categories. In 1973, combining all nest categories, 60 percent of the nests were located in the brome cover while 40 percent were in oat cover. When considering only active and hatched nests, 51 percent of the nests were located in brome cover and 49 percent in oat cover. Using Chi-square analysis, no significant differences ($P > 0.05$) were found between control and experimental treatments for location of nests in these two cover types for all categories of nests combined or when only active and hatched nests were combined.

Table 5. Location of pheasant nests by cover type in 1-acre and 0.5-acre pens, South Dakota fertilizer study, 1.972-73.

	All Nests				Successful Nests			
	Brore[a]		Oats		Brcme"		Oats	
Pens	No.	Percent	No.	Percent	Nc.	Peiccnt	No.	Percent
				1972				
Control	28	85	5	15	13*	93	1*	7
Experiir.er.tal	16	70	7	30	5*	56	4*	44
Total	44	79	12	21	18	78	5	22
				1973				
Control	33	58	24	42	10	50	10	50
Experitr.ental	24	63	14	37	10	53	9	4!
Total	57	60	38	40	20	51	19	49

[a]18-foot border on sides cf pens.
*Significant (P<0.05) difference between treatments for location in cover types.

Hen Survival and Mortality

In 1972, a significant difference ($P<0.05$) was found between numbers of hens surviving in control pens and experimental pens using Chi-square analysis (Table 6). Seventy-three percent of the hens in control pens survived and only 47 percent of the hens in experimental pens survived. Most predation occurred in the one-acre experimental pen, for unexplained reasons, where 70 percent of the originally stocked hens were lost. Remains of 13 percent of the stocked hens were found in the pens. Twenty-seven percent of the hens were not found and were thought to have been removed by avian predators rather than to have flown out since feather regrowth was very slow on clipped wings of hens killed at the end of the study. A total of 60 percent of the stocked hens survived until completion of the study and were considered to be the birds contributing to nesting. In 1973, the experimental design was improved by increasing the number of pens (replications) from four to eight to spread predation more evenly over the pens and treatments. Apparently this was successful because no significant difference ($P>0.05$) was found between number of hens surviving for nesting in control pens and experimental pens using Chi-square analysis. Late mink-killed hens were considered as nesting hens since the final nest search was completed a few days after finding these fresh kills (Table 6). Ninety-eight percent of the control hens were available for nesting and 88 percent of the experimental hens were available for nesting. Remains of four (5%) of the stocked hens were found dead early in the pens. Two hens flew out of the experimental pens at the end of the study. Two hens were not found in the experimental pens and were thought to have been removed early by

Table 6. Number of hens stocked, hen remains found and not found, hens surviving, and hens nesting in 1-acre and 0.5-acre pens, South Dakota fertilizer study, 1972-73.

Pen	Number of Hens				
	Stocked	Remains Found[a]	Fate Unknown	Survived	Nested
			1972		
1-C	20	1	2	17	17
2-C	10	1	4	5	5
Total	30	2	6	22*	22
1-E	20	5		6	6
2-E	10	1		8	8
Total	30	6	10	14*	14
			1973		
1-C	10	8		2	10
2-C	10	4		6	10
6-C	10			10	10
8-C	10	1		9	9
Total	40	13		27	39
3-E	10	3		7	10
4-E	10	1		9	10
5-E	10	6	2	2	5
7-E	10			10	10
Total	40	10	2	28	35

[a]Includes some late mink-killed hens that nested.
*Significant ($P<0.05$) difference between treatments.

avian predators. Eleven of the mink kills were found on July 24. All pens were then searched with pointers in the next few days and the additional victims were found. Usually they were bitten at the base of the skull and some meat on necks and breasts was eaten. Nearly all of the hens were in good enough condition to obtain final weights and remove ovaries. The final bird kill and nest search was made on July 30.

Hen Weight Chances

No significant difference ($P>0.05$) was found in weight changes between control and experimental hens in 1972 using analysis of variance (Table 7). Control hens lost an average of 1.96 ounces and experimental hens lost an average of 2.08 ounces. Also in 1973 no significant difference ($P>0.05$) was found in weight changes between control and experimental hens using analysis of variance. Control hens lost an average of 7.32 ounces and experimental hens lost an average of 6.83 ounces. Increased weight losses in the second year may have occurred because feeding was reduced to further minimize disturbance.

Soil Tests

Soil samples were taken on April 19, 1972 before fertilizer was applied (Table 8). Organic matter averaged 3.2 percent in oat soil for control pens, 3.4 percent in oat soil in experimental pens, 3.9 percent in brome soil in control pens, and 4.0 percent in brome soil for experimental pens, which is slightly higher in brome soil because of more root material (Byrnes 1973). These values are all in the medium rating for South Dakota soils (Carson and Ward 1969).

Table 7. Changes in weights of surviving hens in 1-acre and 0.5-acre pens, South Dakota fertilizer study, 1972-73.

Pens	Average Hen Weights in Ounces[a] ± SD		
	Stocked	End	Change
		1972	
Control	28.3 i- 2.37 (22)	26.3 ± 1.84 (22)	-1.96 ± 2.25 (22)
Experimental	28.2 ± 2.15 (13)	26.1 ± 2.42 (13)	-2.08 ± 3.27 (13)
		1973	
Control	32.2 ± 2.98 (34)	25.2 ± 2.57 (34)	-7.32 ± 2.06 (34)
Experimental	33.6 ± 3.46 (30)	26.8 ± 2.12 (30)	-6.83 ± 3.16 (30)

[a]Number of hens in parentheses.

Table 8. Average soil test results of 1-acre and 0.5-acre control pens compared with experimental pens prior to fertilizer application, South Dakota fertilizer study, 1972-73.

	1972[a]				1973[b]			
	Control Pens		Experimental Pens		Control Pens		Experimental Pens	
Item	Oats(2)[c]	Brome(2)[c]	Oats(2)[c]	Brome(2)[c]	Oats(4)[c]	Brome(4)[c]	Oats(4)[c]	Brome(4)[c]
Organic Matter (%)	3.2	3.9	3.4	4.0	3.9	5.4	3.3	5.2
Phosphorus (lbs/acre)	50	53	36	50	54	62	49	76
Potassium (lbs/acre)	180	288	225	370	269	508	206	446
pH	7.8	7.8	8.1	8.0	7.6	7.5	7.3	7.4
Soluble Salts (Millimhos/cm)	0.30	0.38	0.35	0.36	0.53	0.63	0.41	0.54
Water Soluble Nitrate Nitrogen (ppm)	7.7	13.8	5.8	13.8	9.6	8.1	9.4	6.7
Calcium (ppm)	4200	5500	12,200	10,300	11,450	5950	5250	6700

[a] Soil samples taken on April 19, 1972.
[b] Soil samples taken on April 6, 1973.
[c] Number of pens in parentheses.

Soil samples were taken on April 6, 1973 before fertilization. Organic matter averaged 3.9 percent in oat soil for control pens, 3.3 percent in oat soil for experimental' pens, 5.4 percent in brome soil in control pens, and 5.2 percent in brome soil for experimental pens, which was also higher in brome soil. These values for oat soils are in the medium rating and for brome soils are in the high rating (Ibid).

Phosphorus in 1972 averaged 50 pounds per acre in the oat soil of control pens, 36 pounds per acre in the oat soil of experimental pens, 53 pounds per acre in the brome soil of control pens, and 50 pounds per acre in the brome soil of experimental pens, which are considered high for South Dakota soils except for the oat soil of experimental pens which is medium (Ibid). Phosphorus in 1973 averaged 54 pounds per acre in the oat soil of control pens, 49 pounds per acre in oat soil of experimental pens, 62 pounds per acre in brome soil of control pens, and 76 pounds per acre in brome soil of experimental pens, which are all considered high (Ibid).

Potassium in 1972 averaged 180 pounds per acre for oat soil of control pens and 225 pounds per acre for oat soil of experimental pens which are both in the medium rating for South Dakota soils (Ibid). Potassium averaged 288 pounds per acre for brome soil of control pens and 370 pounds per acre for brome soil of experimental pens, which are in the high rating for South Dakota soils (Ibid). Potassium in 1973 averaged 269 pounds per acre for oat soil of control pens and 206 pounds per acre for oat soil of experimental pens, 508 pounds per acre for brome soil of control pens, and 446 pounds per acre for brome soil of experimental pens, which are all in the high rating except for the oat soil

of experimental pens which is in the medium rating (Ibid).

The acid-base rating (pH) for 1972 was 7.8 to 8.1 or favorable for crop growth (Byrnes 1973). The acid-base rating for 1973 was 7.3 to 7.6 or also favorable (Byrnes 1974).

Soluble salts (rated by conductivity) averaged from 0.30 to 0.38 millimhos per centimeter in 1972 which is in the low range and good for plant growth (Carson and Ward 1969). Soluble salts averaged from 0.41 to 0.63 millimhos per centimeter in 1973 which is also low and good (Ibid).

Water soluble nitrate nitrogen in 1972 averaged 7.7 ppm for oat soil of control pens, 5.8 ppm for oat soil of experimental pens, and 13.8 ppm for brome soils of both control and experimental pens, or normal for South Dakota soils (Byrnes 1973). In 1973, water soluble nitrate nitrogen averaged 9.6 ppm for oat soil of control pens, 9.4 ppm for oat soil of experimental pens, 8.1 ppm for brome soil of control pens, and 6.7 ppm for brome soil of experimental pens, which are normal values (Byrnes 1974).

In 1972, calcium averaged 4200 ppm for oat soil of control pens, 12,200 ppm for oat soil of experimental pens, and 5,500 ppm for brome soil of control pens, and 10,300 ppm for brome soil of experimental pens, which are normal levels for these South Dakota soils (Byrnes 1973). In 1973, calcium averaged 11,450 ppm for oat soil of control pens, 5250 ppm for oat soil of experimental pens, 5950 ppm for brome soil of control pens, and 6700 ppm for brome soil of experimental pens, which are also normal levels (Byrnes 1974).

Soil textures of the 1972 samples were grossly classified as loam, sandy loam, and silty clay loam. Soil textures of the 1973 samples were

grossly classified as loam, sandy loam, and silt loam.

Final 1972 soil samples were taken after fertilization was completed on August 8, in both control and experimental pens (Table 9). Values were averaged for all pens from samples taken before fertilization (April 19) for comparison to changes in control pens over time except for calcium values which were dissimilar (Table 10). Organic matter essentially remained the same from early tests until late tests in the control pens (about 3 percent for oat soil and 4 percent for brome soil) which is a medium rating (Carson and Ward 1969). In 1973, final soil samples were taken on August 7. Organic matter also remained about the same from early tests until late tests in the control pens (about 4 percent for oat soil and 5 percent for brome soil) which is a medium rating for oats and a high rating for brome (Ibid).

Phosphorus in 1972 remained about the same in oat soil with a high rating (Ibid), but decreased from an average of 51 to 41 pounds (both high ratings) per acre in the control pens due to some uptake of this nutrient by plants (Byrnes 1973). In 1973, phosphorus also remained about the same in oat soil with a high rating and decreased from an average of 70 to 50 (both high ratings) pounds per acre in the control pens due to some uptake of this nutrient by plants (Byrnes 1974).

The slight increase in tha average of 202 pounds per acre to 225 pounds per acre (both medium ratings, Ibid) of potassium in oat soil in 1972 probably represents a sampling error rather than an actual increase. Potassium showed a slight decrease in brome soil from 329 pounds per acre to 291 pounds per acre (both high ratings, Carson and Ward 1969) which probably represents a sampling error (Byrnes 1973). The increase of

Table 9. Final soil test averages of 1.0-acre and 0.5-acre control pens compared to experimental pens after fertilizer applications were made in experimental pens, South Dakota fertilizer study, 1972-73.

Item	1972[a]				1973[b]			
	Control Pens		Experimental Pens		Control Pens		Experimental Pens	
	Oats(2)[c]	Brome(2)[c]	Oats(2)[c]	Brome(2)[c]	Oats(4)[c]	Brome(4)[c]	Oats(4)[c]	Brome(4)[c]
Organic Matter (%)	2.8	3.6	3.0	3.8	3.9	4.8	3.5	4.4
Phosphorus (lbs/acre)	47	41	48	42	57	50	67	60
Potassium (lbs/acre)	225	291	244	320	272	555	245	500
pH	7.5	7.5	7.9	7.8	8.0	7.7	7.7	7.5
Soluble Salts (Millimhos/cm)	0.38	0.40	0.40	0.44	0.65	0.61	0.46	0.68
Water Soluble Nitrate Nitrogen (ppm)	10.2	4.9	7.5	3.8	5.8	6.7	5.8	13.9
Calcium (ppm)	4400	5100	13,100	12,000	9630	8570	6105	5805

[a] Soil samples taken on August 8, 1972.
[b] Soil samples taken on August 7, 1973.
[c] Number of pens in parentheses.

Table 10. Soil test results comparison from 1.0-acre and 0.5-acre pens between averages from all pens before fertilization and averages for control pens and experimental pens after fertilization, South Dakota fertilizer study, 1972-73.

	1972					
	Avg. All Pens (April 19)		Control Pens (August 8)		Experimental Pens (August 8)	
Item	Oats	Brome	Oats	Brome	Oats	Brome
Organic Matter (%)	3.3	4.0	2.8	3.6	3.0	3.8
Phosphorus (lbs/acre)	43	51	47	41	48	42
Potassium (lbs/acre)	202	329	225	291	244	320
pH	8.0	7.8	7.5	7.5	7.9	7.8
Soluble Salts (Millimhos/cm)	0.32	0.37	0.38	0.40	0.40	0.44
Water Soluble Nitrate Nitrogen (ppm)	6.7	13.8	10.2	4.9	7.5	3.8
Calcium (ppm)	See Tables 8 & 9		4400	5100	13,100	12,000

Table 10 Continued.

Item	Avg. All Pens (April 6)		1973 Control Pens (August 7)		Experimental Pens (August 7)	
	Oats	Brome	Oats	Brome	Oats	Brome
Organic Matter (%)	3.6	5.3	3.9	4.8	3.5	4.4
Phosphorus (lbs/acre)	52	70	57	50	67	60
Potassium (lbs/acre)	237	477	272	555	245	500
pH	7.4	7.4	8.0	7.7	7.7	7.5
Soluble Salts (Millimhos/cm)	0.47	0.59	0.65	0.61	0.46	0.68
Water Soluble Nitrate Nitrogen (ppm)	9.5	7.4	5.8	6.7	5.8	13.9
Calcium (ppm)	8350	7675	9630	8570	6105	5805

potassium in 1973 from an average of 237 pounds per acre to 272 pounds per acre (from medium rating to high rating) may represent a sampling error. (Byrnes 1974). The increase in-potassium value from 477 pounds per acre to 555 pounds per acre in brome soil (both high ratings) may represent a sampling error (Ibid).

The pH for 1972 remained about the same (7.5-8.0) between early tests for all pens and late tests for control pens. The pH for 1973 also remained about the same (7.4-8.0).

Soluble salts for 1972 remained about the same (0.32-0.44 millimhos per centimeter) between April 19 tests and August 8 tests from control pens which indicated low salinity effects on crops (Carson and Ward 1969). Soluble salts for 1973 also remained about the same between April 6 and August 7 (0.47-0.68 millimhos per centimeter) with low salinity effects on crops (Ibid).

Water soluble nitrate nitrogen in 1972 increased from 6.7 ppm to 10.2 ppm in oat soil probably due to an increased nitrification rate in the top soil and resultant accumulation of this material (Byrnes 1973). Water soluble nitrate nitrogen decreased from 13.8 ppm (average of all pens on April 19) in brome soil to 4.9 ppm on August 8, due to uptake by brome plants (Ibid). Water soluble nitrate nitrogen in 1973 decreased from 9.5 ppm to 5.8 ppm in oat soil probably due to uptake by plants (Byrnes 1974). Water soluble nitrate nitrogen remained about the same (7.4-6.7 ppm) in brome soil.

In 1972 calcium results went from an average of 4200 ppm for control pen oats to 4400 ppm and from 5500 ppm for control pen brome to 5100 ppm probably because of sampling error in both cases (Byrnes 1973).

In 1973 calcium results again remained about the same (8350 ppm to 9630 ppm for oat soil and 7675 ppm to 8570 ppm for brome) over this time period (Byrnes 1974).

Comparison of the 1972 August 8 and 1973 August 7 test results between control and experimental pens are also shown in Table 10. Organic matter in both years remained essentially the same between control and experimental pens but was slightly higher in brome soils in both sets of pens as would be expected from more accumulation of organic material. Phosphorus was about the same in 1972 between control and experimental pens with a high rating (Carson and Ward 1969) from 41 to 48 pounds per acre. Apparently-most additional phosphorus added in the fertilizer was fixed in non-available forms or taken up by plants (Byrnes 1973). Phosphorus in 1973 was slightly higher in both oat and brome soils of the experimental pens than in the control pens (all high ratings) and this was probably a result of fertilization in the experimental pens (Byrnes 1974). It went from 57 pounds per acre in the control pen oat soil to 67 pounds per acre in the experimental pen oat soil and from '50 pounds per acre in the control pen brome soil to 60 pounds per acre in the experimental pen brome soil.

In 1972 potassium levels were higher in the experimental pens. It was 225 pounds per acre in control pens and 244 pounds per acre in experimental pens for oat soil with a medium rating (Carson and Ward 1969) and 291 pounds per acre in control pens and 320 pounds per acre in experimental pens for the brome soil with a high rating (Ibid) as a result of fertilization. In 1973 potassium levels were lower in experimental pens. It was 272 pounds per acre in the control pens and 245 pounds per

acre in experimental pens for oats, 555 pounds per acre in the control pens and 500 pounds per acre in experimental pens for the brome soil, all with a high rating except for the experimental pen oat soil which had a medium rating (Ibid). This was because of sampling error (Byrnes 1974).

The pH remained about the same (7.5-7.90) between experimental and control pens in 1972. In 1973 pH also remained about the same (7.5-8.0) between experimental and control pens.

Soluble salts were slightly higher in experimental pen soils but still had a low rating in 1972 (Carson and Ward 1969). In 1973 soluble salts were about the same between treatments, all with a low rating.

Water soluble nitrate nitrogen was lower in experimental pens in 1972 (10.2 ppm in oat soil for control pens compared to 7.5 ppm in experimental oat soil and 4.9 ppm in control pens for brome soil compared to 3.8 ppm in experimental pen brome soil). Apparently extra nitrogen added by the fertilizer was used by the plants when they were stimulated to more vigorous growth. These levels were normal for South Dakota soils (Byrnes 1973). Water soluble nitrate nitrogen in 1973 was the same (5.8 ppm) in control and experimental pen oat soil but was higher (13.9 ppm) in experimental pen brome soil than in control pen brome soils (6.7 ppm) probably because of extra nitrogen added by fertilizer (Byrnes 1974).

Calcium in 1972 was slightly higher in experimental pens than in control pens. It was 4400 ppm for control pen oat soil, 5100 ppm for control brome soil, 13,100 ppm for experimental oat soil and 12,000 ppm for experimental pen brome soil. Some of this difference could be due to sampling error as well as inherent differences in this element between control and experimental pens (Byrnes 1973). This difference in calcium

is seen in Tables 8 and 9. Additional calcium in experimental pen soil probably would not affect ingestion of fertilizer in the pens by hen pheasants since fertilizer pellet calcium would be a more easily available source of this element. In 1973 calcium remained about the same between treatments or from 6105 ppm to 9630 ppm for experimental and control pen oat soil and from 5805 ppm to 8570 ppm for experimental and control pen brome soil. All of these values are normal for these soils (Byrnes 1974).

Climatological Data

During the 1972 nesting season from May 1 through July 27 (88 days), the total amount of precipitation was 16.28 inches and the greatest amount of precipitation on one day was 2.54 inches (Table 11). According to the South Dakota Crop and Livestock Reporting Service (Potas 1972) as of July 24, precipitation at Brookings was 7.65 inches above normal for the growing season (since April 3). The maximum temperature during the study period was 91 F and was recorded on June 12, June 13, and on July 10. The minimum temperature was 31 F on May 7. No excessive and extended cold or hot periods of air temperature occurred below 32 F and above 90 F that appeared to have detrimental effect on eggs. During the 1973 nesting season from May I through July 27 (88 days), the total amount of precipitation was 5.50 inches and the greatest amount of precipitation on one day was 1.06 inches. According to the South Dakota Crop and Livestock Reporting Service (Potas 1973) as of July 23, precipitation was 4.75 inches below normal for the growing season (since March 26) at Brookings. The maximum temperature for the study period was 94 F

and was recorded on July 7. The minimum temperature was 27 F on May 14. Although six periods occurred with temperatures from 90 to 94 F for one to three days and three periods of from one to two days with 27 to 30 F temperatures, no detrimental effect on eggs was noticed.

Table 11. Climatological data for pen area obtained from the Agricultural Engineering Department Station on campus at South Dakota State University, South Dakota fertilizer study, 1972-73.

Item	1972	1973
Total Precipitation	16.28 inches	5.50 inches
Greatest Amt. Prec./One Day	2.54 inches	1.06 inches
Maximum Temperature	91 F	94 F
Days of Max. Temperature	3	1
Minimum Temperature	31 F	27 F
Days of Min. Temperature	1	1

Experiments in 12 Foot by 12 Foot Pens

Effect of Voluntarily Ingested Fertilizer on Six-Week-Old Pheasants

Survival and Mortality

In 1972 six-week-old game farm pheasants were exposed to fertilizer in 12 foot by 12 foot pens; seven of 120 birds died in experimental pens and five of 120 died in control pens (Table 12). Nine birds died in replication number one of which seven were birds exposed to fertilizer and two were control birds not exposed to fertilizer. Laboratory examination showed fertilizer material in one bird, elevated levels of potassium in two birds, and positive ammonia in one bird (Table 13) while no positive or elevated chemical test results were found in any of the control birds. Only one replication of this experiment was conducted with nine birds in each pen in 1973 and no birds died during one week exposure to fertilizer.

Weight Changes

No significant differences ($P > 0.05$) were found between weight changes of experimental and control pheasants in 1972 by analysis of variance in replications number two and four (Table 14). No weight information was available from the first or third replications. Mean weight gain for experimental birds in replication number two was 75.45 + 24.73 grams standard deviation and for control birds was 84.58 + 28.94 grams standard deviation. Mean weight gain for experimental birds in replication number four was 74.39 + 27.09 grams standard deviation and for control birds was 84.92 + 26.75 grams standard deviation. No valid weights were available from the replication in 1973 because of malfunction of the electronic balance.

Table 12. Number of six-week-old pheasants dying during four replications of one week of exposure to a four-fertilizer mixture[a], total precipitation, and number of fertilizer applications, South Dakota fertilizer study, 1972.

Replication No.	Dates of Experiment	No. Birds in Replication	No. Birds Dying		Total Inches of Precipitation	No. Fertilizer Applications
			Exp.	Control		
1	June 16-25	60[b]	7	2	1.83	2
2	June 30-July 8	60[b]	0	3	1.02	3
3	July 8-15	60[b]	0	0	0.89	2
4	July 15-22	60[b]	0		2.04	4

[a]Ratio of 4:4:1:1 by weight of 34-0-0, 18-46-0, 0-46-0, and 0-0-60.
[b]Thirty in control pens and 30 in experimental pens.

Table 13. Results from chemical tests on six-week-old pheasants dying during the first replication of one week exposure to a four-fertilizer mixture; South Dakota fertilizer study, 1972.

Date Found Dead	Bird Band No.	Pen No.	Results (Positive or Negative to Elevated Fertilizer Chemical), Chemical Found, and Location of the Chemical
6/19	7145	E-7[b]	+ Fertilizer Material Seen (esophagus and crop)
"	3286		+ Potassium (mouth through proventriculus)
it	5684		+ Ammonia (mouth through proventriculus)
	7631	E-8	+ Potassium (in gizzard)
6/20	7140	C-10[c]	-
	7636	C-10	-
n	7159-	E-7	
	5692'	E-8	
6/21	6587,	E-4	

[a]Ratio of 4:4:1:1 by weight of 34-0-0, 18-46-0, 0-46-0, and 0-0-60.
[b]Experimental Pen.
[c]Control Pen.

Table 14. Mean initial weight, mean final weight and mean weight changes ± standard deviation of two replications of six-week-old game farm pheasants when experimental birds were exposed to a four-fertilizer mixture, South Dakota fertilizer study, 1972.

Replication No.	Treatment Group	No.	Mean Initial Weight (grams)	Mean Final Weight (grams)	Mean Weight Change (grams)
2 (June 30-July 8)	Experimental	28	357.11 + 59.38	432.56 + 56.77	75.45 + 24.73
	Control	30	350.80 + 51.44	435.38 + 71.48	84.58 + 28.94
4 (July 15-22)	Experimental	29	397.93 + 54.95	472.36 + 72.36	74.39 + 27.09
	Control	26	414.58 + 72.43	499.30 + 80.79	84.92 + 26.75

Fertilizer Pellet Usage

Significantly more ($P < 0.05$) fertilizer pellets (15 percent) disappeared from one-square-foot plots in experimental pens than from the same size plots outside pens during the first and second replications as determined by analysis of variance in 1972 (Table 15). These results substantiate the contention that six-week-old pheasants voluntarily eat fertilizer scattered on the ground. An average of 24 percent more fertilizer pellets disappeared from the one-square-foot plots in experimental pens than from the same size plots in control pens in 1973. This was not significant ($P > 0.05$) by analysis of variance.

Qualitative Determination of Fertilizer Chemicals in Pheasants Killed

Chemical Tests

To determine if the presence of fertilizer material could be detected in the digestive tracts of six-week-old game farm birds, four birds were placed in a pen and fed scratch grain (flax screenings), and four birds were placed in another pen and fed commercial grower feed on August 3, 1972. The scratch grain was scattered on the ground, and the grower feed was fed in feeders. Fertilizer mixture was scattered on the ground in both pens. Since birds feed the most in late afternoon, they were fed and the pens were fertilized at 2:00 p.m. Two birds in each pen were killed at 5:00 p.m. on August 8. On August 9, the pen was again fertilized with 10.5 ounces or at the rate of 400 pounds per acre (on one-half of the pen plot) at 2:30 p.m. The remaining birds were killed (two in each pen) at 4:30 p.m. this same day.

Table 15. Relative disappearance of fertilizer pellets (100 pellets/pen/date) from experimental pen plots compared to control plots; six-week-old pheasant experiments, South Dakota fertilizer study, 1972-73.

Date	Replication	No. of Pellets Gone From Experimental Pen Plots[a]				No. of Pellets Gone From Control Pen Plots[b]			Mean No. Pellets Gone (Experimental Greater Than Control)
		E-4	E-7	E-8	Average	West	East	Average	
					1972*				
6/18	1	51	60	42	51	39	28	33.5	17.50
6/20		59	71	66	65	49	44	46.5	18.50
6/22		55	70	57	61	49	34	41.5	19.50
6/23		67	80	69	72	57	56	56.5	15.50
								Mean of Means	17.75
7/2	2	71	69	76	72	61	55	58	14.00
7/5		52	65	57	58	43	53	48	10.00
7/6		76	71	68	72	58	63	60	12.00
								Mean of Means	12.00
								Grand Mean	14.88

Table 15 Continued

Date	Replication	No. of Pellets Gone From Experimental Pen Plots[a] E-2	E-4	Average	No. of Pellets Gone From Control Pen Plots[b] West	East	Average	Mean No. Pellets Gone (Experimental Greater Than Control)
				1973				
7/18		75	61	68	44	41	42	26
7/19		45	41	43	26	26	26	17
7/20		44	34	39	0	11	6	33
7/21		39	44	42	0	19	10	32
7/23		62	50	56	44	41	42	14
							Mean of Means	24

[a]mn pen with six-week-old pheasants.
[b]In pen without pheasants.
*Treatment differences significant ($P<0.05$).

Previous experience with pheasants force-fed the four fertilizer formulations indicated high positive phosphorus (P reagent) levels in all birds tested, no reaction with Shales and Shales Chloride test and calcium (Sulkowitch) positive for only the 0-46-0 formulation.

Only positive ammonia tests and potassium results greater than nine milliequivalents per liter was indicative of ingestion of the four-fertilizer mixture according to experiments previous to 1972. Of the four birds killed on August 8, only the two in the grower pen indicated high potassium results. None of these birds showed a positive ammonia result. All of the birds killed on August 9 showed high positive results for potassium and negative results for ammonia. In 1973, the experiment was repeated. On July 26, the birds were fed and fertilizer was applied in both pens at 2:30 p.m. The birds were killed at 4:30 p.m. the same day. Of the four birds killed, all had high potassium levels. Only the two birds in the pen with grower feed had positive ammonia results and they had full crops while the two birds in the pen with scratch grain had empty crops (Table 16). Because of this additional variation in results and the possibility of the positive results of ammonia being due only to the presence of more feed in the crop, control birds were also killed during the second killing. .Two experimental birds were in one pen with scratch grain and two were in the pen with grower feed. In addition, three control birds were placed in another pen with scratch grain and three more controls in a pen with grower feed. All pheasants were fed at 1:45 p.m. on August 2 and the experimental pens were fertilized. The birds were killed at 4:45 p.m. and tested for chemicals. No set pattern existed for presence of ammonia and potassium levels in this experiment

Table 16. Potassium and ammonia test results (mouth through proventriculus), six-week-old pheasant kill experiments, South Dakota fertilizer study, 1973.

7/26 Experiment					8/6 Experiment				
Band No.	Pen	Crop Condition	Potassium (Milliequivalents/ liter	Ammonia	Band No.	Pen[c]	Crop Condition	Potassium (Milliequivalents/ liter	Ammonia
7317	G[a]	Full	25.1	+	7879	EG	Full	25.1	
7391	G	Full	25.1	+	7937	EG	Full	25.1	
7940	S[b]	Empty	14.7		7308	ES	Empty	18.1	
7935	S	Empty	11,4		7892	ES	Empty	19.4	+
					7313	CG	Full	25.1	
					7938	CG	Full	25.1	
					7942	CG	Empty	25.1	
					7309	CS	Part Full	12.3	
					7878	CS	Full	25.1	
					7895	CS	Full	25.1	+

[a] Grower feed pen.
[b] Scratch grain feed pen.
[c] E=experiment (exposed to fertilizer), C=control not exposed to fertilizer).

(Table 16).

Seven cock pheasants were killed in the 1973 hunting season to test for occurrence of ammonia and potassium in the digestive tracts. It was very unlikely that birds had access to fertilizer in the field at that time of the year. All seven were negative for ammonia and varied from low to high for potassium (Table 17). It appeared from these results that the potassium test would have little value to prove that an adult pheasant had ingested fertilizer. However, birds positive for ammonia may indicate ingestion of fertilizer by adults.

Fertilizer Pellet Usage

Although it appeared in 1972 that more fertilizer was taken from the one-square-foot plots in the two experimental pens than from the plot outside the pen, the difference was not significant ($P>0.05$) by analysis of variance (Table 18). In 1973 during the first kill experiment on July 26, no pellets were eaten from the one-square-foot plots (Table 18). During the second kill experiment on August 2, only 14 pellets of the 34-0-0 formulation were eaten from the one-square-foot plot in the pen with grower feed. No pellets were eaten from the one-square-foot plots in the pen with scratch feed and none disappeared from the control plots.

The 34-0-0 and 18-46-0 formulations were eaten in greater amount in the experimental pen in 1972 where grower feed was used than in the control pen (22.3 percent and 2.5 percent more respectively, Table 19). More (5 percent) of the 34-0-0 formulation was eaten in the experimental pen where scratch grain feed was used than in the control pen. All pellets of the 0-46-0 and 0-0-60 formulations remained on the one-square-foot plots during

Table 17. Potassium and ammonia test results, adult wild cocks shot in the fall of 1973, Brookings County, South Dakota fertilizer study, 1973.

Pheasant	Potassium (Milliequivalents/liter)	Ammonia
1	12.4	
2	12.7	
3	19.3	
4	5.1	
5	10.9	
6	18.4	
7	2.9	

Table 18. Relative disappearance of fertilizer pellets (100 pellets/ pen/day) from one-foot-square plots in experimental pens compared to control pen plots, six-week-old pheasant kill experiments, South Dakota fertilizer study, 1972-73.

Date	No. Pellets Gone From Scratch Grain Pen	No. Pellets Gone From Grower Pen	No, Pellets Gone From Control Pen
	1972		
8/8	36	47	11
8/9	16	14	4
	1973		
7/26	0	0	0
8/2	0	14	0

Table 19. Relative disappearance of different formulations of fertilizer pellets from one-square-foot plots in experimental pens compared to control plot, six-week-old pheasant kill experiments, South Dakota fertilizer study, August 9, 1972.

	Grower Pen			Scratch Pen			Control Plot		
Formulation	Pellets Applied	Pellets Gone	% Gone	Pellets Applied	Pellets Gone	% Gone	Pellets Applied	Pellets Gone	% Gone
34-0-0	40	13	32.3	40	6	15	40	4	10
18-46-0	40	1	2.5	40	0	0	40	0	0
0-46-0	10	0	0	10	0	0	10	0	0
0-0-60	10	0	0	10	0	0	10	0	0

the two-day experiment.

Experiments in Battery Brooders

Survival and Chemical Tests

Two experimental chicks and one control chick died during three replications of exposure of three-day-old pheasants (total of 31 birds) to the four-fertilizer mixture in 1972 (Table 20). Another chick became sick in an experimental brooder and was removed and frozen. One of the experimental brooder chicks that died showed elevated potassium results, and the sick pheasant from the experimental battery brooder that was frozen showed elevated_ ammonia and potassium results. The other two chicks (one control and one experimental) died when the power to the heater was accidentally cut off during the night. They showed neither positive ammonia nor elevated potassium results. Four chicks (40 percent) died in the experimental brooder during one replication in 1973 (Table 21). Three live control chicks of the same age from another brooder were sacrificed and tested on January 29 when the first three experimental chicks died. Three additional live control chicks were sacrificed on February 1. The fourth experimental chick died on February 4. None of the 10 chicks died in the control brooder during the experiment. Birds dying in the experimental brooders had more than 1.99 milliequivalents per liter of potassium in the esophagus and crop and the control birds less than 1.99 milliequivalents per liter. Variable results were obtained with the ammonia test. During the two years, 1 (2 percent) control chick died, and 6 (15 percent) chicks died that were exposed to fertilizer.

Table 20. Potassium and ammonia test results[a] from three-day-old pheasant chicks in batter brooders, South Dakota fertilizer study, 1972.

Band No.	Potassium (Milliequivalents Per Liter).	Ammonia
Experimental		
3471	25.1	
3861	1.6	
3873[b]	10.4	+
Control		
3869	3.5	

[a]Gastrointestinal tracts from the mouth through posterior proventriculus.
[b]Chick removed when sick and frozen for tests.

Table 21. Potassium and ammonia test results from three-day-old pheasant chicks in battery brooders, South Dakota fertilizer study, 1973.

Band No.	Potassium (Milliequivalents Per Liter)	Ammonia
Experimental (1-29-74)		
7040[ac]	16.2	+
7042[a]	7.1	+
7045[a]	2.0	-
Control (1-29-74)		
7058[a]	1.1	-
7059[b]	0.0	-
7064[b]	0.8	-
Control (2-1-74)		
7051[a]	0,4	
7053[b]	0,6	
7061[b]	1.9	+
Experimental (2-4-74)		
7054[a]	2.1	

[a]Died in brooder.
[b]Submitted alive.
[c]Crop full.

Weight Changes

No significant difference (P>0.05) occurred in weight change between treatment groups by analysis of variance in 1972 (Table 22). Mean weight gains were from 21.04 + 7.96 grams standard deviation to 51.40 + 6.71 grams standard deviation for experimental birds during the three replications and from 35.11 + 7.76 grams standard devation to 53.00 + 9.08 grams standard deviation for control birds. In 1973 no significant difference (P>0.05) occurred in weight change between treatment groups by analysis of variance. Mean weight gain was 33.25 + 6.17 grams standard deviation for control birds and 30.27 + 3.39 grams standard deviation for experimental birds.

Fertilizer Pellet Usage

Three-day-old pheasants were observed eating pellets of all four formulations in 1972. Little difference was found in individual pellet counts of the three formulations (18-46-0 and 0-46-0 data were combined because these pellets were the same gray color after one day elapsed) (Table 23). During the four periods of this replication, an average of 73 percent of the 34-0-0 formulation was removed daily by the birds, 72 percent of the combined 18-46-0 and 0-46-0 formulations, and 70 percent of the 0-0-60 formulation.

During replications two and three, when a weighed amount of the four-fertilizer mixture was added to the brooders, it was possible to separate out and weigh remaining pellets of different formulations for three periods of time (Table 24). It was not possible to separate the 34-0-0 formulation from the 0-46-0 formulation since they both appeared

Table 22. Mean initial weight, mean final weight and mean weight changes + standard deviation of three replications of three-day-old game farm pheasants when experimental birds were exposed to a four-fertilizer mixture in battery brooders, South Dakota fertilizer study, 1972-73.

Replication No.	Treatment Group	No. Birds	Mean Initial Weight (grams)	Mean Final Weight (grams)	Mean Weight Change (grams)
1972-1[a]	Experimental	10	27.27 + 1.79	78.60 + 7.12	51.40 + 6.72
	Control	11	26.55 + 3.20	79.54 + 11.66	53.00 + 9.08
1972-2	Experimental	10	28.70 + 2.41	59.82 + 5.98	31.12 + 4.60
	Control	10	28.30 + 4.16	71.90 + 9.67	43.60 + 5.88
1972-3	Experimental	8	24.70 + 3.48	45.74 + 10.87	21.04 + 7.96
	Control	a	26.86 + 3.76	61.97 + 11.04	35.11 + 7.76
1973	Experimental	6	24.25 ± 1.56	54.52 + 2.83	30.27 + 3.39
	Control	10	22.42 ± 1.91	55.67 + 7.17	33.25 + 6.17

[a]This replication lasted 13 days; the others were seven days.

Table 23. Relative disappearance of different formulations of fertilizer pellets from experimental battery brooders, replication one; three-day-old game farm pheasants, South Dakota fertilizer study, 1972.

Date	Total No. Pellets (at 4:4:1:1 Ratio)	Percent of Pellets Gone[a]			
		34-0-0	18-46-0 and 0-46-0	0-0-60	Average
6/17 to 6/18	100	63	62	50	58
6/18 to 6/19	200	75	73	85	78
6/19 to 6/20	200	75	79	80	78
6/20 to 6/21	300	80	73	63	72
Average	200	73	72	70	72

[a] 34-0-0 was a white color, 18-46-0 was dark gray, 0-46-0 was light gray to brown, and 0-0-60 was red. The 18-46-0 formulation could not be distinguished from the 0-46-0 formulation after one day.

Table 24. Relative disappearance of different formulations of fertilizer pellets from battery brooders, replications two and three; three-day-old game farm pheasants, South Dakota fertilizer study, 1972-73.

Dates of Exposure to Fertilizer	Grams of Fertilizer								
	34-0-0[a] and 0-46-0[a]			18-46-0			0-0-60		
	Amount Presented	Amount Gone	Percent Gone	Amount Presented	Amount Gone	Percent Gone	Amount Presented	Amount Gone	Percent Gone
1972									
7/7 to 7/9	30	24.6	82	24	16.2	68	6	0	0
7/15 to 7/20	45	38.9	86	36	24.1	67	9	1.9	21
7/20 to 7/22	30	26.0	87	24	17.2	72	6	1.6	26
Average	35	30	85	28	19	69	7	1	16
1973									
1/28 to 2/4	60	30	50	75	17	23	15	3	20

[a]Could not be separated in the brooder litter.

gray. The 18-46-0 formulation appeared brown and the 0-0-60 formulation was red in color. The 18-46-0 formulation was utilized at the higher rate of 69 percent compared to only 16 percent of the 0-0-60 formulation for replications two and three. Since it was not possible to separate the 34-0-0 formulation from the 0-46-0 formulation, it can only be said that 85 percent of their combined material was removed by the study birds. In 1972 disappearance of total fertilizer material as determined by weights for the three replications averaged 47 percent and ranged from 73 percent during the first replication to 25 percent during the second replication (Table 25). The study chicks probably ate most of this material; however, a small amount was kicked out of the brooders and a small undetermined amount was covered and dissolved in the pheasant feces and therefore not recovered for the final weights. Experimental chicks were again observed to eat fertilizer pellets in 1973. In two instances a bird appeared sick. On the fourth day a chick was observed to eject a fertilizer pellet and push pellets away with its bill to get at feed crumbs. This possibly indicated it had learned not to eat fertilizer pellets. In 1973, 50 percent of the 34-0-0 formulation was eaten, 23 percent of the combined 18-46-0 and 0-46-0 formulation material was eaten and 20 percent of the 0-0-60 formulation was eaten (Table 24). In 1973, 33 percent of the total fertilizer material was eaten (Table 24).

Force-Feeding Experiments

Reproductive Performance

No difference was found between treatment groups for egg production ($P>0.05$) by analysis of variance in 1972, and percent fertility of eggs laid by hens that were force-fed the four-fertilizer mixture (Table

Table 25. Disappearance of fertilizer from experimental battery brooders, three-day-old game farm pheasants, South Dakota fertilizer study, 1972-73.

Date	Replication	Fertilizer Available (grams)	Fertilizer Gone[a] (grams)	Percent/Day
		1972		
6/22	1	30	23.6	79
6/23		30	22.9	76
6/24		30	22.1	74
6/25		30	21.3	71
6/26		30	20.8	69
6/27		30	20.5	68
Average		30	22	73
7/2	2	30	8.90	30
7/4		30	5.75	19
7/5		60	4.75	14
7/6-7/7		25.25	14.85	30
7/7-7/9		60	40.13	33
Average		41	15	25
7/15-7/20	3	90	64.89	14
7/20-7/22		60	44.82	38
Average		75	55	26
			Avg. All Replications	47
		1973		
1/28-2/4	1	150	50	33

[a]Chicks ate most, but a small amount was probably kicked out of brooders.

Table 26. Reproductive statistics from control pheasants and pheasants given fertilizer, South Dakota fertilizer study, 1972.

Treatment Group mg Fertilizer Weekly	Period[a]	No. Eggs Set In Incubator	Fertility Fertile[b]	Fertility Not Fertile	Fertility Percent Fertile[c]	Hatchability Hatched	Hatchability Not Hatched	Hatchability Percent Hatched	Pipping Pipped	Pipping Not Pipped	Pipping Percent Pipped[d]
0	1	114	72	42		49	23		6	17	
	2	90	61	29		48	13		2	11	
	3	59	41	18		29	12		2	10	
	Totals	263	174	89	66	126	48	72	10	38	21
100	1	79	46	33		39	7		2	5	
	2	84	38	45		24	15		1	14	
	3	68	19	49		11	8		0	8	
	Totals	231	104	127	45	74	30	71	3	27	10
300	1	93	51	42		34	17		4	13	
	2	101	66	35		47	19		5	14	
	3	54	29	25		20	9		1	8	
	Totals	248	146	102	59	101	45	69	10	35	22
900	1	129	96	33		69	27		4	23	
	2	105	85	20		61	24		3	21	
	3	78	51	27		44	7		6	1	
	Totals	312	232	80	74	174	58	75	13	45	22

[a]Each period consisted of 5 weeks.
[b]No. of eggs with at least one day of development.
[c]Percent of fertile eggs.
[d]Percent of fertile eggs not hatched.

26). Fertility was 74 percent in the 900--milligram group, 66 percent in the control group (0 milligrams), 59 percent in the 300-milligram group, and 45 percent in the 100-milligram group. There was no significant difference ($P>0.05$) between treatment groups for hatchability of fertile eggs using Chi-square analysis (Table 26). Hatchability was 72 percent for the control group and from 69 to 75 percent for the three fertilizer groups. There was also no significant difference ($P>0.05$) of pipping rates between treatment groups for the fertile eggs not hatched, using Chi-square analysis (Table 26). Pipping percentage was 21 percent for the control group and from 10 to 22 percent for the three fertilizer groups. In 1973 no significant difference ($P>0.05$) occurred in egg production between treatment groups (Table 27).

Eggshell Thickness

In 1972 there was no significant difference ($P>0.05$) between treatment groups for eggshell thickness by analysis of variance (Table 28). Eggshells from hatched eggs (without membranes) laid by control hens averaged 0.25 + 0.02 mm standard deviation, and averages from all groups receiving fertilizer ranged from an average of 0.23 + 0.01 mm standard deviation to 0.24 + 0.03 mm standard deviation. Eggshells from unhatched eggs laid by control hens averaged 0.32 + 0.04 mm standard deviation, and averages from those from all hen groups receiving fertilizer ranged from 0.29 + 0.04 mm standard deviation to 0.31 +0.03 mm standard deviation.

Survival of Hens

Of the six control hens and 18 experimental hens force-fed fertilizer in 1972, only three died during the study. One bird died from the

Table 27. Eggs laid by control pheasants and pheasants given fertilizer, South Dakota fertilizer study, 1973.

Treatment Group (mg Fertilizer weekly)	Period"	Eggs Laid
0	1	87
	2	56
	3	37
Totals		180
100	1	84
	2	64
	3	69
Totals		217
300	1	92
	2	49
	3	78
Totals		219
900	1	68
	2	69
	3	88
Totals		225

[a]Each period consisted of 5 weeks.

Table 28. Mean eggshell thickness ± standard deviation in millimeters for control and fertilizer groups, South Dakota fertilizer study, 1972.

Treatment Group (mg Fertilizer Weekly)	Hatched Eggs		Unhatched Eggs	
	Number of Eggs	Shell Thickness	Number of Eggs	Shell and Membrane Thickness
0	111	0.2456 ± 0.0202	119	0.3172 ± 0.0390
100	81	0.2435 ± 0.0314	158	0.2895 ± 0.0382
300	87	0.2264 ± 0.0068	132	0.2907 ± 0.0408
900	166	0.2384 ± 0.0235	134	0.3085 ± 0.0267

300-milligram group after the final (17th) weekly pill administration and two birds died in the 900-milligram group also after the 17th pill administration. Necropsy reports by the Veterinary Diagnostic Laboratory at SDSU did not reveal hemorrhages in muscles or other mortality characteristics that could be indicative of fertilizer ingestion; nevertheless, these birds probably died from fertilizer ingestion, Of the six control hens and 18 experimental hens force-fed fertilizer in 1973, only one died in the 900-milligram group during the fourth week of 17 weeks of pill administration. The death of this hen was due to an accident whereby the hen caught itself on a sharp wire in the cage and bled to death. None of the hens died from fertilizer ingestion that year. Therefore for the two years, only 3 (8%) of the 36 experimental birds died from fertilizer ingestion.

Hen Weight Changes

In 1972 and 1973, no significant differences ($P>0.05$) were found between treatment groups in weight changes of the 24 force-fed hens each year during any of the 16 weekly periods when weights were taken, using analysis of variance (Table 29).

Crippling of Chicks

In 1972 no significant differences ($P>0.05$) were found between treatment groups in incidence of crippling in offspring using Chi-square analysis. Only four percent of the chicks were born crippled in the control group, one percent in the 100-milligram group, and two percent in each of the 300 and 900-milligram groups.

Table 29. Original average weights and periodic average weight changes of control hens and hens given fertilizer, South Dakota fertilizer study, 1972-73.

Week of Treatment		Average Weight Change in Grams[a]							
		1972				1973			
		0 mg Group	100 mg Group	300 mg Group	900 mg Group[b]	0 mg Group	100 mg Group	300 mg Group	900 mg Group
	Avg. Original Wt.	1183.3	1104.8	1205.3	1218.5	1211.5	1373.3	1287.2	1338.3
1		14.8	2.2	-11.6	12.7	-15.3	22.8	-34.5	-1.0
2		27.8	-11.0	-12.2	12.8	-17.2	-42.0	9.8	-16.3
3		45.3	8.5	-11.2	10.0	-23.0	-31.5	-51.5	-21.7
4		73.3	9.7	1.5	71.0	-26.7	-26.2	-33.3	-5.2
5		34.0	-15.5	-22,3	12.0	-15.0	-1.3	3.5	6.2[d]
6		25.5	-11.8	-25.3	46.2	-15.0	-5.8	-7.2	3.4
7		9.7	1.3	9.8	17.2	-5.7	-5.2	-6.3	3.6
8		97.3	-0.2	-8.3	12.7	-23.7	-9.5	-17.0	4.4
9		23.0	-2.7	9.2	23.8	-13.3	-6.0	-9.7	1.2
10		28.5	7.7	-23.8	10.5	2.5	-8.0	-4.7	1.8
11		20.8	2.0	-35.2	-4.7	-8.5	-2.5	11.5	8.6
12		32.5	2.0	-61.2	41.2	180.8	32.7	-29.7	-20.4

Table 29 Continued

Week of Teamont	Average Weight Change in Grams[a]							
	1972				1973			
	0 mg Group	100 mg Group	300 mg Group	900 mg Group	0 mg Group	100 mg Group	300 mg Group	900 mg Group
13	3.0	-14.2	-79.3	49.7	-14.2	0.17	-1.3	-11.2
14	-28.7	-21.7	-97.0	28.2	6.7	16.3	-9.8	11.4
15	-64.2	-36.8	-89.0[b]	48.2[c]	6.7	-12.8	3.8	-72.0
16					103.0	-26.5	-25.8	-8.6

[a] Each group had 6 hens.
[b] One hen died in this group.
[c] Two hens died in this group.
[d] One hen died in this group.

Visual Cliff Performance

No significant difference (P>0.05) was found in performance on the visual cliff between treatment groups using Chi-square analysis (Table 30). When combining data from all treatment groups, 73 percent of the chicks jumped to the shallow side and 27 percent jumped to the deep side.

Response to Hand Catching

Results of catching young pheasants by hand were analyzed by comparing the number of birds from each treatment group caught in the first half and last half of all birds caught to an expected number equaling 50 percent of birds in that group. No significant differences (P>0.05) were found between treatment groups in numbers caught in halves (Table 31). Fifty-two percent of the control group and of the 900-milligram group birds were caught in the first half of all birds caught, 54 percent of the 100-milligram group birds were caught in the first half of all birds caught, and 53 percent of the 300-milligram group birds were caught in the first half of all birds caught.

Survival and Weights of Offspring

No significant difference (P>0.05) was found by Chi-square analysis between treatment groups for survival of offspring until six weeks (Table 32). Seventy-four percent of the chicks produced from control hens survived until six weeks and from 69 to 77 percent of the chicks produced by hens receiving fertilizer survived. Differences between average six-week-weights of offspring were not significantly different (P>0.05) among treatment groups by analysis of variance (Table 32).

Table 30. Visual cliff performance of pheasant chicks produced by hens receiving 0, 100, 300, and 900 mg per week; South Dakota fertilizer study, 1972.

Treatment Group	Number of Chicks	Decision of Chicks		
		Shallow	Deep	Percent Deep
0 mg	96	76	20	21
100 mg	55	39	16	29
300 mg	77	55	22	29
900 mg	155	111	44	28
Total	383	281	102	27

Table 31. Effects of fertilizer on hand capture of penned pheasants, South Dakota fertilizer study, 1972. (Numbers represent birds caught in the first half of all birds caught; numbers in parentheses represent birds caught in the second half of all birds caught. Chi-square was used to compare numbers caught in halves with half of the total number in each category.)

Dates of Capture	mg of Fertilizer Parents Received Weekly 0	100	300	900	Total
July 9	17 (18)	14 (13)	16 (11)	31 (30)	150
August 1	26 (22)	20 (13)	21 (16)	38 (34)	190
August 16	31 (26)	16 (14) .	22 (22)	40 (36)	207
August 30	32 (28)	19 (15)	22 (25)	50 (43)	234
September 13	28 (27)	15 (17)	27 (21)	44 (40)	219
October 6	23 (25)	16 (14)	24 (23)	40 (37)	202
Total	157 (146)	100 (86)	132 (118)	243 (220)	1202
Percent Caught 1st Half	52	54	53	52	

Table 32. Weights ± standard deviation and survival for the first six weeks of offspring from control pheasants and pheasants given fertilizer, South Dakota fertilizer study, 1972.

Treatment Group mg Weekly	Average Weight at 6 Weeks (grams)	No. of Chicks to Brooder	No. of Chicks Alive After 6 Weeks	Percent Survival
0	365.93 + 72.80	109	81	74
100	377.54 + 67.27	70	52	74
300	375.85 + 65.02	96	66	69
900	385.48 + 61.16	163	126	77

Average weight of 81 chicks produced by control hens was 365.93 + 72.80 grams standard deviation and ranged from an average of 375.85 + 65.02 grams standard deviation to an average of 385.48 + 61.16 grams standard deviation for 244 chicks produced by hens receiving fertilizer.

SUMMARY AND CONCLUSIONS

Survival, reproduction and body weights were not adversely affected in 1972 and 1973 for adult wild pheasants exposed to recommended pelleted fertilizer applications in 1.-acre and 0,5-acre fields with oat and brome-grass cover. Soil tests taken before and after fertilization showed normal levels of soil nutrients and chemicals and in some cases appeared to indicate normal incorporation of fertilizer nutrients and chemicals into soils and plants of experimental pens. Climatological data showed that 1972 was an abnormally wet year and 1973 an abnormally dry year. No excessive cold or hot temperatures occurred that had adverse effects on pheasant eggs.

Only one percent mortality of six-week-old game farm pheasants was attributed to fertilizer ingestion and this occurred when birds were under stress from lack of adequate commercial feed. Weights of surviving birds were not affected by fertilizer ingestion. In 1972 significantly more fertilizer pellets disappeared from experimental pens than from control plots and more also disappeared in 1973, but this difference was not significant.

Six-week-old pheasants allowed to eat fertilizer at their own volition and control birds not allowed to eat fertilizer, then killed and tested for fertilizer chemicals showed no individual pattern between treatments (control versus experimental) in occurrence of these chemicals. More fertilizer pellets were eaten in experimental pens than disappeared from control plots. Preference was evident for the 34-0-0 formulation and secondly the 18-46-0 formulation over the others,

Greater mortality (15 percent) occurred among three-day-old pheasant chicks exposed to fertilizer pellets than chicks in control pens. Chicks were observed to eat all formulations of fertilizers. The largest kill occurred in 1973 when three chicks were found dead the second day of the experiment. These chicks were under abnormal stress from being wing banded and handled the previous day. Fertilizer ingestion did not affect the weights of the surviving chicks. Experimental chicks generally preferred the 34-0-0 formulation, followed by the 18-46-0 formulation over the 0-46-0 and the 0-0-60 formulations. They ate from 25 to 73 percent of the fertilizer placed in the brooders.

Game-farm pheasants fed 100 mg, 300 mg, and 900 mg of fertilizer weekly had only eight percent mortality (one died in the 300-mg group and two died in the 900-mg group). Reproductive performance, eggshell thickness, hen weight changes, crippling incidence in chicks, behavior of chicks (tested by visual cliff and hand-catching), and survival and weights of offspring (at six weeks) were not affected by the fertilizer mixture fed to the breeding hens.

Potassium levels in the crop-gastric tracts of seven wild-cock pheasants killed in the fall of 1973 were high but variable, and tests for ammonia were negative. Potassium levels probably have little value as an indicator of ingested fertilizer by adults. Positive ammonia tests, however, might indicate fertilizer ingestion. When examining wild birds suspected of dying from fertilizer ingestion, the digestive tracts from the mouth through the posterior proventriculus should be removed and tested immediately or frozen until tested. Other birds that were not exposed to the fertilizer should be collected and tested as controls.

Considering the results of all experiments conducted during this study, it appears unlikely that fertilizer adversely affects reproduction of wild pheasants in agricultural areas of South Dakota. Probably some direct mortality occurs from ingestion of fertilizer pellets by pheasant chicks and adult birds, but it is unlikely that this constitutes a significant portion of overall pheasant mortality.

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