Economic and Environmental Risk Efficiency Analysis of Land Application of Cattle Feedlot Manure: Generalized Stochastic Dominance Analysis

by

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Abstract

GSD is used to determine the risk efficiency of nine different technologies of land application. The analysis shows that organic applications for crop phosphorus needs are the most environmentally efficient. Under producer risk aversion, inorganic fertilizer application is the most economically desirable. Organic applications can be both environmentally amenable and economically viable alternatives in the long run.

Key Words: Generalized Stochastic Dominance, Risk Efficiency, Land Application, Environment, Phosphorus, Nitrate, Water Pollution.

JEL CODE: C93, D81, Q25.

Introduction

The growing environmental concerns are putting pressure on both livestock and crop farmers in terms of various policy regulations. With intensification of livestock operations disposal of manure has become an important environmental issue (Zilberman et al. 1996). Manure is an excellent plant nutrient source that contains most of the elements required for plant growth and can be substituted for inorganic fertilizer. Other noted advantages of manure are: improvement in soil structure, water holding capacity and increased infiltration rates that are associated with enrichment of soil organic matter (Eghball and Power 1994).

Most beef cattle feeding is concentrated in Central and Southern Great Plains. At any given time there are at least 10 million head of beef cattle on feed in the U.S.A. (USDA, 1997). Of the rations fed to cattle about 80% of nitrogen (N) and other nutrients in the grain passes through the animal into excreta. Computed based on daily excretions per head per day, approximately 529,900 tons of N are excreted annually in the beef feedlot manure. In addition manure is composed of comparable quantities of phosphorus (P) and potassium (K) which amount to 157,000 tons and 482,000 tons respectively. The estimated fertilizer value of feedlot manure based on nutrient (N, P, and K) contents is about $461 million (Eghball and Power 1999). This resource has largely been ignored in U.S. agriculture and has been often disposed by the cheapest method possible. Fertilizer value of manure can only be obtained if it is distributed according to crop needs. If manure is not effectively distributed, it becomes an environmental hazard that can potentially pollute ground and surface waters with N and P. Environmental regulations requiring proper land application of manure in an environmentally safe manner has not always been preceded by adequate research to provide the means to maximize both the economic and environmental potential of manure as a crop fertilizer (Christensen, 1999).

From the producers' point of view inconvenience of handling, transportation, and application costs outweigh the benefits in the short-run. In addition, there is a risk involved in not being able to properly manage livestock waste so as to ensure environmental standards stipulated by the Department of Environmental Quality (DEQ). Apart from that, variability in the available nutrient content in manure and compost can also influence production risk associated with inadequate supply of required nutrient to the crop.

Perceived risk of innovative farming practices and new technologies affect potential for widespread adoption of such practices. It will further influence the extension efforts and policy making. The response of farmers to agricultural and environmental policy is heavily influenced by the riskiness of their production practices (Hien et al. 1997). This paper sets out to analyze land application of feedlot manure and compost within the framework of perceived environmental and economic risk of such practices. We use generalized stochastic dominance approach to evaluate risk efficiencies of four different manure and compost application alternatives and compare the same to traditional fertilizer application on corn crop under dryland conditions in eastern Nebraska.

General Objectives

The general objective of this paper is to analyze the economic and environmental risk efficiency of farming practices that use manure or compost as a potential substitute for commercial fertilizer. These are compared to the standard practice of commercial fertilizer use on corn in Eastern Nebraska. Specific objective is to find how compatible are the alternative practices with respect to DEQ objectives of cleaner water bodies and producers' objective of maximum returns with lower economic risk.

Method

Generalized stochastic dominance analysis (Meyer 1977a) is used to determine the risk efficient technologies under the assumption that producers maximize profits within a given risk framework. Environmental risk efficiency is analyzed for DEQ objectives. Due to lack of or non-existence of information on damage functions, we use experimental data on residual NO_3-N levels found below the root zone (36-48 in. soil depth) and P levels found in the surface soils (0-6 in.) after each season as potential contributors to ground and surface water pollution. A simplifying assumption made here is that the higher the residual N and P quantities found in soil after cropping season at these respective soil depths, the greater will be the potential for contamination of water bodies in the environment through leaching and runoff. Further we assume that DEQ's preferences are built into the regulatory standards and policies. For instance we consider 10 mg/l NO_3-N limit in the ground water, stipulated by EPA represents the upper tolerance level for its preference for clean water. Similarly 0.09 mg/l upper limit adopted by Nebraska DEQ for P is taken as the upper tolerance level for P contamination of surface water.

Generalized Stochastic Dominance (GSD)

Stochastic dominance with respect to a function (Meyer 1977a) has been widely used in agricultural economics (McCarl 1988). The basis of GSD lies in the expected utility hypothesis. It can be used in a manner that allows the ranking of the decision strategies consistent with expected utility maximization. This is accomplished by reducing the choice set of alternatives to a smaller subset. The GSD insures that the strategy which has the highest expected utility for a specified class of admissible utility functions is included in the subset. This subset is referred to as the efficient set with respect to risk behavior of decision maker.

Let g(x) and f(x) be two different distributions and G(x) and F(x) be their cumulative counterparts. Dominance with GSD is demonstrated when the utility function which minimizes the integral;

$\int_{-\infty}^{\infty}[G(x)-F(x)]*U'(x)dx$ is found and the sign of the integral is still positive. The utility function is constrained to lie in the preference interval such that, $r_1(x) < -UNN(x)/UN(x) < r_2(x)$. This corresponds to the identification of the function in the admissible class which is least likely to result in the expected utility of F being greater than G. If it can be shown that F is preferred to G for that utility function, then it is known that result will hold for the entire class of admissible utility functions. Algorithm written by Cochran and Raskin (1988) provides the ability to calculate GSD efficient set with all of the pair-wise comparisons. In addition, it calculates the premiums associated with a dominant distribution. The premium is the amount that a decision maker would be willing to pay for the use of dominant strategy (Cochran and Mjelde 1987). Upper and lower bounds on the premium are interpreted as estimates of the value of information contained in the dominant distribution.

Data

Data from field experiments conducted at the University of Nebraska Agricultural Research Center near Mead, Nebraska is used for the analysis. Research on land application of manure has been conducted since 1992 and still on-going. Data used in this paper is for the years from 1993 through 1997. Experimental area consists of Sharpsberg silty clay loam soil. The experimental design is randomized complete block with four replications of ten treatments (Eghball and Power 1999). Crop selected is corn which is extensively grown throughout the region. Ten treatments are: annual manure application for N requirement of corn (MN); bi-annual manure for N (MN2Y); annual manure for P (MP); bi-annual manure for P (MP2Y); same four treatments for compost applications denoted as CN, CN2Y, CP, CP2Y respectively; nitrogen fertilizer application and a control. Manure and compost were applied to provide 135 lbs N/ac and 23 lbs P/ac for an expected yield of 150 bu/ac (Gilbertson et al. 1979). If necessary, the P based treatments also received N fertilizer as ammonium nitrate in the Spring so that a total of 135 lbs N/ac was available for the crop. Soil NO_3-N and NH_4-N levels and P_2O_5 - P levels were determined up to a depth of 4 feet at the end of each season to monitor the soil N and P status. The hauling and application costs of manure only up to a one mile distance were calculated based on the Massey (1995) manure application cost analyzer program. Manure application rate of 20 tons/ac was used in cost calculations with varying amounts needed to fertilize land based on N and P requirement of the crop. Only hauling and distribution costs plus ownership and operating costs were considered in computations. Cost of manure was considered zero. Composting, transportation, and spreading costs were calculated following Lesoing et al. (1996). They range from \$3.75/ton to \$6.00/ton. All other costs were estimated based on Nebraska crop budgets for the years 1993-1997 and were converted to 1992 constant dollar values. Returns (to land, management and fixed capital) were calculated for each system using yields and 1992 constant dollar prices for corn to avoid stochastic price variations and to isolate stochastic yield variations.

In assessing the potential environmental risk, inverse of NO_3-N content moving to the vadose zone (unsaturated soil horizon between root zone and water table) is taken as a proxy index for environmental friendly technology. Most of the roots of corn plant is distributed in the upper three feet, therefore, NO_3-N available below three feet can not be utilized by plants. The underlying assumption is that there is a direct relationship between NO_3-N leached below the root zone and ground water pollution due to N. In the absence of relevant technical parameters that aid in determining the movement of NO_3-N in the soil this assumption can be regarded plausible (Yadav 1997). Therefore, the higher the index the more amenable to the environment the technology would be. Similarly the inverse of P contents found in the surface layers of the soil (0-6 in.) were taken as a proxy index for P loading from fields to the surface waters. As an index for N and P contamination, one could even consider the inverse of applied N or P plus residual minus crop uptake as a good formulation. This adds sophistication to the index but not value to the analysis.

Many previous researches that have adopted GSD method in analyzing alternative choices under conditions of uncertainty have used either assumed or elicited risk aversion coefficients (Raskin and Cochran 1986). Some have used calculated risk aversion coefficients based on the upper bound of the outcome under study (Giesler et al. 1993). We use calculated Pratt Arrow coefficient in this analysis. The RAC upper bounds ($\mathbf{r_b}$) used in this study for environmental efficiency ranking of technologies are 0.10 for NO_3-N contamination, and 0.09 for phosphorus contamination. These RAC's were based on upper bounds set by the DEQ for these respective contaminants. The calculated upper bound for economic efficiency ranking of technologies is 0.00305. Lower bounds ($\mathbf{r_a}$) were set at negative of the calculated values so as to capture the full range of risk attitude regime. Systematic iterative procedure was adopted in searching the highest value of the $\mathbf{r_b}$ of a given interval that will allow the complete ranking of all the alternatives. The per-acre outcome values were scaled up using the average farm size in the eastern Nebraska as 380 acres (Nebraska Agriculture, 1996-1997) to represent whole farm values. Since the invariance property of affine transformation applies only to the utility function but not to the outcome values, per acre interval bounds were divided by 380 to preserve the meaningfulness of ranking (Cochran and Raskin 1986). Risk premiums were calculated using what we identify as the relevant range or the risk averse range.

Results

Given in the table 2 is the rankings of technologies for environmental efficiency with respect to potential NO_3-N contamination. Rankings were calculated up to 27 intervals because attempts to combine these intervals resulted in type II errors (inability to rank). Even though ranking results were produced for a wide range of risk behavior, ranging from risk neutral to moderate risk aversion to high risk aversion, we consider only the intervals from 17-27 as the relevant range given the objectives of DEQ. When DEQ is considered as a highly risk averse agent with respect to NO_3-N contamination, raw manure application and fertilizer ranked lowest in the array. What is environmentally efficient is mostly compost application technologies for crop P needs. The results agree with agronomic findings that compost application for P requirement of the crops leads to the lowest soil accumulation of not only soil N but also soil P. Most manure application technologies are ranked higher in risk neutral intervals. Given our assumption that DEQ is a risk averse agent, this range is irrelevant for policy decisions. Compost application technologies ranked high because compost contribute to the N pollution least due to the fact that it contains N in more stable forms. Table 1 shows the ranking for P contamination. Unlike NO_3-N contamination, we were able to combine most of the intervals without encountering type II errors. In this case complete ranking of all the alternatives were possible within 11 intervals. Efficient set includes MP which is significantly dominant throughout the entire spectrum of risk behavior. However, commercial fertilizer and CP are ranked immediately following MP. All the organic applications for crop N requirements are ranked low. It indicates that if P contamination is a significant environmental threat, manure and compost applications for crop N needs are highly environmentally inefficient within the DEQ risk regime. Under such conditions even commercial fertilizer fares better compared to most organic application for crop N needs. These results tally with proven agronomic findings. So DEQ as a risk averse agent would prefer P based land applications or fertilizer under such circumstances. Table 4 shows the economic risk efficiency rankings based on net whole-farm income. We consider here the interval 9 as the break-even risk aversion limit. From interval 1 to 9 which we refer to as risk neutral range biannual manure application ranked higher. Nevertheless, even in risk neutral range commercial fertilizer ranked immediately behind. Apart from yield variability (table 5) the cost differentials involved in composting, hauling, and spreading can be a major factor in these results. Cost differentials among compost and manure technologies are arising partly from variability in N and P contents in manure and compost and partly from variable frequency of applications. In what we refer to as risk averse range (intervals 10 through 19) commercial fertilizer dominated all other alternatives. CP, MP2Y, and MN2Y ranked higher even in the risk averse range. This may be attributed to long term nutrient stabilization effects and "organic effect" that improves the yields.

As can be noticed from descriptive yield statistics (table 5) compost application for P requirement along with supplemental N through fertilizer has resulted higher average yields compared to commercial fertilizer application alone. Yet the dominance of commercial fertilizer technology over CP with respect to economic risk efficiency may be attributed more to cost differentials even though yield differentials are not insignificant. Apparently short term economic risk causes the fertilizer to be more efficient compared to other alternatives which can be more environmentally friendly. The very same effect can be noticed by looking at risk premium results (table 3). Premiums presented in table 3 can be attributed to compound effect of both the yield risk as well as to the cost differentials across technologies. However, they are more comparable to cost differentials than that arising from risk associated with yield variability. Therefore, in the absence of significant yield variability across higher ranking technologies, these cost differentials may be what is reflected in premiums. In this case the maximum that CP technology users would be willing to pay to use commercial fertilizer is estimated at $49/ac in each and every state of nature. The upper bound for the premiums for MP2Y and MN2Y are $85/ac and $88/ac respectively. In comparison to commercial fertilizer application, bi-annual compost and annual manure application technologies are the least desirable in economic terms. The most interesting result that can be noticed here is that with $20/ac reduction in returns commercial fertilizer will be in the same efficient set with CP, MP2Y and MN2Y. This could be due to observable yet unquantifiable effects brought about by organic applications. However, looking at overall picture, one can infer that environmental objectives of DEQ and economic objectives of producers are not diverging forces.

Concluding Remarks

GSD analysis aid the identification of risk efficient practices from a range of alternatives within a specific risk characterization of producers and DEQ, an agent preferring for quality environment. In this study producer risk as well as DEQ preferences are incorporated through risk aversion parameters. It was shown that different risk aversion parameters yield different optimal combinations of risk management. The analysis indicated that under the specific assumption of DEQ risk aversion, manure application for crop P need is the most efficient in environmental terms when potential exists for pollution due to P loading from fields. Our results also indicate that among nine different technologies considered compost application for crop N needs was the most efficient if DEQ is concerned with potential contamination due to NO_3-N arising from land application. However, as one moves from risk neutral to the risk averse range, most compost application technologies move forward in ranking. Therefore, compost applications appear to be more desirable when potential contamination risk exists due to NO_3-N. Ranking for economic efficiency indicated fertilizer as the most risk efficient practice closely followed by CP, MP2Y, and MN2Y. It appears to be the case that environmental objectives of DEQ and economic objectives of producers are not irreconcilable when land application is considered a viable alternative for commercial fertilizer. Complementarities seem to exit but not in the short-run. The results presented can not be generalized across all conditions. They can vary depending on soil physical characteristics, economic conditions, and producers and agency risk behaviors. Nevertheless, they can be used as guidelines in environmental policy formulations. Incentives may be designed based on relative premium differences between environmentally sound and economically efficient technologies. The optimum nutrient management strategies designed to meet realistic crop needs is the most important factor in reducing pollutants such as P and NO_3-N. It is also important to recognize that some aspects of fertilizer use in agriculture are not justified by environmental concerns per se but reflect individual risk preferences.

Table 1. Ranking of Technologies for Phosphorus Contamination Based on Risk Preferences.

Interval	Risk Aversion Coefficient		Environmental Efficient[a] Ranking of Technology
	Lower Bound	Upper Bound	
1	-0.000237	-0.000164	MP, FERT, CP, CP2Y, MP2Y, MN2Y, MN, CN, CN2Y
2	-0.000162	-0.000139	MP, FERT, CP, CP2Y, MP2Y, MN2Y, MN, CN, CN2Y
3	-0.000137	-0.000114	MP, FERT, CP, CP2Y, MP2Y, MN2Y, MN, CN, CN2Y
4	-0.000113	-0.000014	MP, FERT, CP, CP2Y, MP2Y, MN2Y, MN, CN, CN2Y
5	-0.000013	-0.000011	MP, FERT, CP, CP2Y, MP2Y, MN2Y, MN, CN, CN2Y
6	0.000012	0.000036	MP, FERT, CP, CP2Y, MP2Y, MN2Y, MN, CN, CN2Y
7	0.000037	0.000135	MP, FERT, CP, CP2Y, MP2Y, MN2Y, MN, CN, CN2Y
8	0.000137	0.000185	MP, FERT, CP, CP2Y, MP2Y, MN2Y, MN, CN, CN2Y
9	0.000186	0.000210	MP, FERT, CP, CP2Y, MP2Y, MN2Y, MN, CN, CN2Y
10	0.000211	0.000235	MP, FERT, CP, CP2Y, MP2Y, MN2Y, MN, CN, CN2Y
11	0.000236	0.000237	MP, FERT, CP, CP2Y, MP2Y, MN2Y, MN, CN, CN2Y

a. Ranking is based on least to most potential for phosphate pollution due to run off arising from manure, compost and chemical fertilizer application to experimental corn plots over five year period.

Table 2. Ranking of Technologies for NO_3-N Contamination Based on Risk Preferences.

Interval	Risk Aversion Coefficient		Environmental Efficient[a] Ranking of Technology
	Lower Bound	Upper Bound	
1	-0.026316	-0.005177	MP, CN, MP2Y, MN, CP, CN2Y, MN2Y, FERT, CP2Y[b]
2	-0.005165	-0.004902	MP, CN, MP2Y, MN, CP, CN2Y, MN2Y, FERT, CP2Y
3	-0.004890	-0.004077	MP, CN, MP2Y, MN, CP, CN2Y, MN2Y, FERT, CP2Y
4	-0.004065	-0.003527	MP, CN, MP2Y, MN, CP, CN2Y, MN2Y, FERT, CP2Y
5	-0.003515	-0.002427	MP, CN, MN, MP2Y, CP, CN2Y, MN2Y, CP2Y, FERT
6	-0.002415	-0.001602	MP, CN, MN, MP2Y, CP, CN2Y, MN2Y, CP2Y, FERT
7	-0.001612	-0.000700	MP, CN, MN, MP2Y, CN2Y, CP, CP2Y, MN2Y, FERT
8	-0.000686	-0.000330	CN, MP, MN, MP2Y, CN2Y, CP, CP2Y, MN2Y, FERT
9	-0.000320	-0.000150	CN, MP, MN, MP2Y, CN2Y, CP, CP2Y, MN2Y, FERT
10	-0.000136	0.000035	CN, MP, MN, MP2Y, CN2Y, CP, CP2Y, MN2Y, FERT
11	0.000047	0.000218	CN, MP, MN, MP2Y, CN2Y, CP, CP2Y, MN2Y, FERT
12	0.000230	0.000768	CN, MN, MP, MP2Y, CP, CN2Y, CP2Y, MN2Y, FERT
13	0.000778	0.001389	CN, MN, MP, CP, MP2Y, CP2Y, CN2Y, MN2Y, FERT
14	0.001401	0.001600	CN, MN, MP, CP, MP2Y, CP2Y, CN2Y, MN2Y, FERT
15	0.001612	0.001811	CN, MP, MN, CP, MP2Y, CP2Y, MN2Y, CN2Y, FERT
16	0.001823	0.002233	CN, MP, MN, CP, MP2Y, CP2Y, MN2Y, CN2Y, FERT
17	0.002245	0.003710	CN, CP, MP, CP2Y, MN, MP2Y, MN2Y, CN2Y, FERT
18	0.003720	0.004397	CN, CP, MP, CP2Y, MN, MP2Y, MN2Y, CN2Y, FERT
19	0.004409	0.005397	CN, CP, CP2Y, MP, MN, MN2Y, MP2Y, CN2Y, FERT
20	0.005409	0.008041	CN, CP, CP2Y, MP, MN, MN2Y, MP2Y, CN2Y, FERT
21	0.008053	0.010685	CN, CP, CP2Y, MP, MN, MP2Y, MN2Y, CN2Y, FERT
22	0.010697	0.013329	CN, CP, CP2Y, MP, MN, MP2Y, CN2Y, MN2Y, FERT
23	0.013341	0.015973	CN, CP, CP2Y, MP, MN, CN2Y, MP2Y, MN2Y, FERT
24	0.015984	0.018616	CP, CN, CP2Y, MP, CN2Y, MN, MP2Y, MN2Y, FERT
25	0.018629	0.021260	CP, CN, CP2Y, MP, CN2Y, MN, MP2Y, FERT, MN2Y
26	0.021272	0.023904	CP, CN, CP2Y, MP, CN2Y, MN, MP2Y, FERT, MN2Y
27	0.023916	0.026316	CP, CN, CP2Y, MP, CN2Y, MN, MP2Y, FERT, MN2Y

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a. Ranking is based on least to most potential for NO_3 pollution of ground water due to manure, compost and chemical fertilizer application to experimental corn plots over 5 year period.

b. MN = Annual manure application for N requirement of the crop; MP = Annual manure application for P; MN2Y = Bi-annual manure application for N; MP2Y = Bi-annual manure application for P.

Nomenclature is the same for compost application. FERT = commercial fertilizer application.

Table 3. Risk Premiums of Dominated Technologies Compared to Dominant Technology.

Technology	Risk Premium ($/ac)[a]	
	Lower Bound	Upper Bound
Dominant Technology: FERT		
MN	40.73	128.20
MP	27.09	146.32
MN2Y	13.06	88.10
MP2Y	20.87	84.52
CN	65.78	91.53
CP	10.11	49.14
CN2Y	60.16	107.63
CP2P	27.30	116.35

[a] Premiums were calculated for the risk aversion range of $r_a = 0.000043$ to $r_b = 0.000802$.

Table 4. Ranking of Technologies for Economic Risk Based on Net Whole Farm Income.

Interval	Risk Aversion Coefficient		Ranking of Technology For Economic Efficiency[a]
	Lower Bound	Upper Bound	
1	-0.000802	-0.000396	MP2Y, MN2Y, FERT, CP2Y, CP, MN, CN2Y, MP, CN
2	-0.000395	-0.000315	MP2Y, MN2Y, FERT, CP2Y, CP, MN, CN2Y, MP, CN
3	-0.000314	-0.000233	MP2Y, MN2Y, FERT, CP2Y, CP, CN2Y, MN, MP, CN
4	-0.000232	-0.000180	MP2Y, MN2Y, FERT, CP, CP2Y, CN2Y, MP, MN, CN
5	-0.000170	-0.000120	MP2Y, MN2Y, FERT, CP, CN2Y, CP2Y, MP, MN, CN
6	-0.000119	-0.000090	MP2Y, MN2Y, FERT, CP, CN2Y, CP2Y, MP, MN, CN
7	-0.000089	-0.000046	MP2Y, MN2Y, FERT, CP, MP, MN, CP2Y, CN2Y, CN
8	-0.000045	-0.000002	MP2Y, MN2Y, FERT, CP, MP, MN, CP2Y, CN2Y, CN
9	-0.000001	0.000042	FERT, CP, MN2Y, MP2Y, CN, CN2Y, CP2Y, MN, MP
10	0.000043	0.000086	FERT, CP, MN2Y, MP2Y, CN, CN2Y, CP2Y, MN, MP
11	0.000087	0.000130	FERT, CP, MN2Y, MP2Y, CN, CN2Y, CP2Y, MN, MP
12	0.000131	0.000306	FERT, CP, MN2Y, MP2Y, CN, CN2Y, CP2Y, MN, MP
13	0.000307	0.000336	FERT, CP, MN2Y, MP2Y, CN, CN2Y, CP2Y, MN, MP
14	0.000338	0.000418	FERT, CP, MN2Y, MP2Y, CN, CN2Y, CP2Y, MN, MP
15	0.000419	0.000499	FERT, CP, MP2Y, MN2Y, CN, CN2Y, CP2Y, MN, MP
16	0.000500	0.000581	FERT, CP, MP2Y, MN2Y, CN, CN2Y, CP2Y, MN, MP
17	0.000582	0.000662	FERT, CP, MP2Y, MN2Y, CN, CN2Y, CP2Y, MN, MP
18	0.000663	0.000743	FERT, CP, MP2Y, MN2Y, CN, CN2Y, CP2Y, MN, MP
19	0.000745	0.000802	FERT, CP, MP2Y, MN2Y, CN, CN2Y, CP2Y, MN, MP

[a] Ranking is based on whole farm net returns. Hauling, distribution, and application of manure and compost only up to 1 mile distance is considered in this calculation.

Table 5. Yield Distributions and Descriptive Statistics.

	Yields (bu/ac)								
Year	MN	MP	MN2Y	MP2Y	CN	CP	CN2Y	CP2Y	FERT
1993	142.33	160.28	150.11	143.71	109.23	119.39	149.79	113.98	130.15[1]
	150.65	126.05	135.30	153.14	106.15	149.00	122.19	141.82	131.86[2]
	120.92	151.62	140.48	131.38	70.95	111.94	83.58	110.02	125.07[3]
	139.83	123.00	124.71	139.76	131.19	117.76	135.19	111.90	135.18[4]
1994	159.14	155.64	176.26	141.37	131.55	170.17	145.16	133.20	174.30
	158.80	148.17	174.77	143.37	147.82	181.33	112.34	181.84	151.41
	123.29	141.99	127.32	139.84	130.11	107.53	125.65	145.18	142.42
	164.08	160.80	162.37	199.08	159.84	178.25	173.26	153.14	157.05
1995[e]	25.41	59.74	52.12	38.57	84.13	51.15	65.37	56.49	76.68
	66.63	70.48	33.30	45.20	65.70	80.49	84.73	95.73	75.23
	27.75	56.55	63.61	37.86	59.69	64.78	66.23	26.86	73.97
	49.81	19.14	58.96	77.99	88.51	73.78	89.42	68.60	67.92
1996	112.59	137.70	160.36	114.33	149.82	144.61	97.40	153.30	124.47
	121.13	129.37	129.88	135.83	134.12	152.58	120.88	115.22	84.68
	117.07	156.34	132.59	110.71	123.33	135.00	86.95	134.14	149.01
	132.86	121.14	113.08	124.34	131.71	124.61	154.56	137.69	116.07
1997	178.84	169.08	160.88	163.06	163.66	146.04	162.64	126.84	175.94
	143.64	151.73	150.69	151.39	148.35	162.44	146.42	172.00	169.02
	128.61	105.18	175.79	184.78	157.58	164.06	156.33	149.38	157.51
	156.57	173.42	136.01	164.24	156.19	180.50	159.71	140.01	156.44
Mean	121.00	125.87	127.93	127.00	122.48	130.73	121.89	123.37	128.72
Std. Dev.	43.42	42.64	42.00	44.14	32.28	38.72	33.31	37.27	34.56
Min.	25.41	19.14	33.30	37.86	59.69	51.15	65.37	26.86	67.92
Max.	178.84	173.42	176.26	199.08	163.66	181.33	173.26	181.84	175.94
Skewness	-1.14	-1.23	-1.04	-0.85	-0.66	-0.58	-0.25	-1.02	-0.54

1 = Replicate No. 1; 2 = Replicate No. 2; 3 = Replicate No. 3; 4 = Replicate No. 4.

e = unusually dry year.

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