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ENERGY AND ECONOMIC RETURNS FROM CATTLE DUNG AS MANURE AND FUEL

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Abstract—We have studied the fuel use of cattle dung. Data on substitution for fertilizers by farm yard manure formed the basis of this work. The use of dung as fuel is more efficient than its use as manure. Dung (after providing energy for manufacturing fertilizers equal to the nutrient content of the dung in India) used as fuel will provide power equal to 2000 ME_e, which is 1.3 times the power generation capacity of the Punjab.

INTRODUCTION

The use of cow dung as manure is a practice as old as recorded history. A reference occurs in the Rig Veda, which may be the oldest book of the world. Researches on farm manure illustrate the importance of animal manures as a source of plant nutrients. According to Tunney,[1] livestock wastes play an important part in world food production. However, total dependence on organic sources of plant nutrients to manure crops may not be a wise step in view of the ever-increasing demand for food and fibre. New, high yielding varieties have made inorganic fertilizers indispensable for increasing crop production. In India, a four-fold rise occurred in the consumption of inorganic fertilizers in 8 years (1966–67 to 1973–74).

Increases in oil prices have been responsible for a steep rise in fertilizer prices. Thus, the world price of urea jumped from \$45–50/t in 1971 to \$200–380/t in 1974. This increase has been a great drain on the exchange resources of India. The need to maintain growth in food production in the wake of the energy crisis forced agricultural scientists to find renewable energy alternatives to energy-intensive inorganic fertilizers. This endeavour brought back cattle manure and other organic manures as substitutes for inorganic fertilizers. Several studies have been made to quantify the substitution of inorganic fertilizers by cattle manure. Agricultural scientists claim that burning of almost 50% of the available cowdung in India deprives the country of a cheap and natural fertilizer and thus make a case to discourage the use of dung as a fuel. In fact, India's National Commission on Agriculture[2] declared that "the use of cowdung as a source of non-commercial fuel is virtually a crime".

In an effort of saving cowdung for manuring, we tend to overlook fuel shortages. India's fuel wood needs in the year 2000 will be 250×10^6 mt; present requirements are 170×10^6 mt[3]. For more than a third of the world's people, the real energy crisis is a daily scramble to find the fuel needed to cook dinner.[4] The FAO document, "Agriculture: Towards 2000"[5] points out that, with fuelwood production expected to fall short by 40%, many poor people will not be able to cook their food adequately.

The prevailing situation of simultaneous shortage of food and fuel highlights the importance of judicious use of available farm manure either for raising food production or for cooking food as both are essential for the survival of mankind. Daily fuel requirements of a villager are 8895 kcal[6] as compared to 2500 kcal of needed food energy. These requirements correspond to a daily national requirement of 6.1×10^{12} kcal as fuel energy and 1.7×10^{12} kcal as food energy. How best the easily available cowdung could be used to meet partly these energy needs to the country is the subject of our analysis.

METHODOLOGY

The study is based on several field experiments conducted on sandy loam soil (mixed, hyperthermic, typic ustochrept), which was low in organic matter (0.41% carbon), in order to

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quantify the reduction in fertilizer dose with farm yard manure (FYM) in cereal-based crop rotations. Pertinent information about these experiments is given below.

Experiment 1: Economy of N and P through FYM in rice–wheat rotation

FYM was applied to rice in rice-wheat rotation. The 14 combinations of treatments included 2 levels of FYM (0 and 12 t/ha), 4 levels of nitrogen (0, 40, 80, and 120 kg/ha), and 4 levels of phosphorus (0, 20, 40, and 60 kg P_2O_5/ha). Residual effects of FYM on wheat are also quantified.

Experiment 2: Studies on the causes of low wheat yield in rice–wheat rotation

Wheat yields less as a crop following rice as compared to its yield after maize. The possible causes for this yield loss are being studied in a long term experiment with rice–wheat and maize–wheat rotations. The treatments imposed on wheat following rice include (i) recommended doses of NPK, (ii) additional 25% N, (iii) additional 25% NPK, (iv) additional 25%P, and (v) 15 t FYM/ha.

Experiment 3: Fertilizer saving through FYM in maize–wheat rotation

A long term experiment on manure requirement of maize–wheat rotation with 3 levels of P_2O_5 (0, 30, and 60 kg/ha), 2 levels of K_2O (0 and 30 kg/ha) and 2 levels of FYM (0 and 15 t/ha) was conducted for 10 years. In another experiment, 2 levels of FYM were combined with different rates of N to maize. The yield data for these experiments was processed to quantify the possible reduction in N, P_2O_5, K_2O, and Zn doses with application of FYM to maize.

Experiment 4: N substitution by organic manures in maize

The substitution of fertilizer N with different organic manures, i.e. cowpea, guar, sesbania, and 12 D. FYM/ha in maize–wheat rotation is under study since 1979–80. The experiment includes five levels of N, viz., 0, 50, 75, 100, and 125 kg N/ha applied to maize following treatment with green manures and farm yard manure. Residual effects of manures and N on the next wheat crop also studied.

Full nutrient value of the manure is not available to the crop as it is not completely decomposed during the growing season. The crops that follow too benefit from nutrients released from the previously applied manure. Manures also increase soil productivity by improving organic matter content and soil physical properties. To account for these additional benefits of manures, total yield of the crop rotation (2 crops/yr) averaged at least over 3 years in the experiments were used to compute energy and economic returns from cowdung used as manure. Energy needed to produce one kg of fertilizer N, P, and K was taken as 16, 850, 3550, and 2440 kcal, respectively.[7] These values include energy consumed in production, transportation, storage, and application of fertilizers. The energy value of one kilogram of a micronutrient fertilizer was considered to be equal to that of a P fertilizer. Since micronutrients are used in small quantities any deviation in actual production energy will cause only minor changes in the energy budget.

Moisture content of the cowdung, determined at the time of its mixing in the field, varied from year to year. Consequently an average value of moisture content (60%) was used to calculating the fuel value of the cowdung. The heat energy equivalent of dry drung was considered to be 3.0 kcal/g[8] and its thermal efficiency 11%.[9] The relative efficiency has been calculated as the ratio of energy obtained by burning dung to energy saved by using it as manure.

The economic analysis of using dung as manure or as fuel is based on current prices of fertilizers and various fuels. The heating values of firewood, soft coke and kerosene oil are 3.3, 5.77, and 11.0 kcal/g, respectively and their efficiencies (cooking) are 0.20, 0.18, and 0.51.[10] The cost of preparing dung cakes for burning is about one fourth of the cost of dung.

FINDING AND CONCLUSIONS

The rice yield with 12 t FYM and 80 kg N was the same as with 120 kg N/ha. The residual effect of FYM on wheat equalled 30 kg N and 30 kg P_2O_5.[11] Loss in wheat yield when the crop followed rice rather than maize could be avoided by using 15 t FYM or 25% additional NPK as

Table 3. Total nuteients (in 10^6 t) in dung, urine and farm wastes available in India for agricultural purposes; the data are from Ref. 13, except for the energy values, which are given in 10^{13} kcal).

Source	Total quantity	N	P_2O_5	K_2O	Micro-nutrients	Energy value
Fresh dung	630	1.26	0.63	0.94	0.20	2.46
Urine	100	0.60	0.10	0.50	not known	1.14
Farm wastes	85	0.34	0.09	0.34	not known	0.66

in Nigeria that a good case could be made for the often condemned peasants custom of using dung as fuel. This is also true in many situations in India. For example, owing to the scarcity of fuel wood in dryland farming areas, burning is good use of this local energy source. Its ashes can be used as a source of plant nutrients. The net loss is only of nitrogen, sulphur and some phosphorus. Gobar gas plants offer the most efficient use of cowdung as manure and fuel sources. These should be encouraged where manure is readily available. There are, however, several limitations to universal installation of gobar gas plants. We should, therefore, support the use of cattle dung for cooking food by millions of Indians who do not have access to a cheaper fuel for their hearths.

It is of interest to examine the situation when all dung in India is burnt for cooking food (Table 3). Burning of dung will yield far more energy (4.22×10^{13} kcal) than corresponds to the energy value of total nutrients, inclusive of micronutrients, contained in dung and dung plus urine. A net advantage of power equal to 2000 MW_e, which represents 1.3 times the power generation capacity of the Punjab with a population of 16.7×10^6, is available from burning dung cakes even after providing for the energy consumed to manufacture fertilizers equivalent to the nutrients present in the cowdung and 25% urine mixed with dung.

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Table 1. Ameliorative effect of FYM on wheat in rice-wheat rotation: source: Annual Reports (1979, 1980, 1981). Department of Soils, Punjab Agricultural University.

Additional dose to wheat	Additional energy 10^6 Kcal	Wheat	Rice	Total	Relative efficiency
		q/ha			
nil	0	45.2	63.8	109.0	-
15 t FYM	3.92	47.1	64.2	111.3	1.0
25 % N	0.51	50.0	61.8	111.8	6.0
25 % NPK	0.56	51.2	61.7	112.0	5.6
25 % P	0.023	49.6	65.0	114.6	136.0

fertilizers (Table 1). Thus, 1 t FYM as a substitute for commercial fertilizers saved 1.02×10^5 and 0.37×10^5 kcal of energy in Experiments 1 and 2, respectively. However, burning 1 t FYM as dung cakes will provide 2.1×10^5 kcal of effective fuel energy.

Reductions in fertilizer dose with 15 t FYM to maize in Experiment 3 equal 40, 60, 30, and 5 kg of N, P_2O_5, K_2O, and Zn, respectively. The fertilizers are applied according to the practices of the farmers.[12] Results of Experiment 4 revealed that, in maize-wheat rotation, 12 t FYM hardly substituted for 75 kg N. Thus, the energy equivalents of 1 t FYM as a substitute for commercial/chemical fertilizers were 0.56×10^5 and 1.05×10^5 kcal in experiments 3 and 4, respectively, while 2.1×10^5 kcal of effective fuel energy could be made available when the same quantity of FYM is burnt in an Indian village hearth as dung cakes.

The relative efficiency varied from 2.05 to 5.6 in rice-wheat rotation and from 2.0 to 4.68 in maize-wheat rotation. Energy expenses in the manufacture of fertilizers equivalent to the total nutrient contents (N, P, K and essential micronutrients) of 1 t FYM are 1.43×10^5 kcal. On this basis, the relative efficiency (1.26) is such that using cattle dung as a fuel is favored.

The economic worth of 1 t FYM as a substitute for commercial fertilizers varied from Rs. 18 to 48 as compared to saving of firewood worth Rs 154 when the dung is burnt (Table 2). Thus, the maximum economic return in using dung as manure are barely one third of the possible returns from its use as fuel.

These analyses reveal that use of cattle dung as a fuel gives higher energy and economic returns than its use as manure. Keen (1946), as quoted by Das,[14] observed from his experience

Table 2. Comparative economic returns (in Rs/t) from dung used as manure or fuel.

Experiment No.	Manure	Use of dung as Fuel		
		Kerosene oil	Coke	Wood
1. N & P economy	45.00	72.80	166.40	154.40
2. Ameliorative	10.30-18.40	-	-	-
3. Manurial	48.10	-	-	-
4. N substitution	38.60	-	-	-