7.4 Quantity and quality of farmyard manures

How much manure can a farm produce and what amounts of nutrients will it make available to crops? Innumerable variations are possible on the route from fresh dung and urine to usable farmyard manure, the effectiveness of which is correspondingly diverse.

The simplest case would involve stabling livestock with almost no variation in fodder and litter supply. The amount of manure that would thus be obtained can be roughly estimated using a formula by SAUERLANDT (1948): x kg dung/day + y kg of dry litter/day times the number of days the animals are stabled.

According to this formula, 10 goats would produce about 7 t of manure.[118] The amount of manure produced annually by a dairy cow kept all day in the stable is roughly 10 t (naturally moist). For India, with the same form of stabling, ARAKERI et al. (1962) measured 6-8 t of farmyard manure per cow per year. In Africa, 7 t is a realistic estimate per TLU with permanent stabling and litter (MINISTERE DE LA COOPÉRATION 1980). The amount of manure that a farm has available in practice is usually considerably less than the estimates given here.

In northern Côte d'Ivoire, SCHLEICH (1985) studied draft oxen stabled with litter overnight. He measured an output of 2.2-4.4 t of fresh manure per animal per year (average 3.3 t) or 1.0 to 2.2 t of dry dung. This is about a third to half the theoretical amount. Far smaller amounts of dry dung were obtained when the animals were kept on the savanna and driven into a pen with no roof for the night. This husbandry system entails no special care for the dung, which is merely collected once a year. It is of poor quality, having been exposed to the trampling of the animals, to sun and to rain, and being mixed with earth. At about 0.2 t of dry dung or 0.4-0.5 t of fresh matter per TLU, the manure yield under this form of stabling amounts to only a fifth of what could be obtained if the animals were stabled nightly with litter and to less than a tenth of the amount achieved with permanent stabling. KOTSCHI et al. (1991) report 6 t/TLU for semi-permanent deep litter stabling in Rwanda.

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[118] Naturally moist, containing 3 kg of litter per day.

It is obviously difficult to generalize concerning the nutrient contents of manures (or dry dung) obtained in such different ways. Table 7.7 summarizes some of the data.

Through on-site analysis, it should be possible to calculate the nutrient contents that can be expected from each method of storage. The nutrient ratio of cattle manure is approximately 10:5:13 ($N:P_2O_2:K_2O$). For nitrogen, some 30% to 60% of the total can be regarded as available, depending on soil and climate (McCALLA 1975; FLAIG et al. 1978).

Table 7.7. Nutrient contents (%) of different manures from different origins

Type of manure	N	P_2O_5	K_2O	CaO	MgO	Author
Cow manure (naturally moist) (Côte d'Ivoire)	0.5-0.6	0.2-0.8	0.8-1.4	0.4-0.9	0.3-0.6	GODEFROY (1979)
Cow manure (naturally moist) (Germany)	0.5	0.25	0.7	-	-	SAUERLAND (1948)
Cow manure (DM) (West Africa)	0.5-1.9	0.2-1.3	0.5-3.1	-	-	MOKWUNYE (1980)
Cow dung (DM, from pit) (Côte d'Ivoire)	1.5	0.6	1.1	0.7	0.4	SCHLEICH (1985)
Sheep manure (DM) (India)	1.4	0.2	1.0	3.5	-	SINGH & BALASUBRAMANIAN (1980)
Sheep dung (DM) (Côte d'Ivoire)	1.0	0.6	1.4	0.9	-	SCHLEICH (1983)

The availability of P and K corresponds to that of mineral fertilizers. The effect of the P may even be better, because not so much P is soluble at one time as, for example, with superphosphate, so less fixation takes place. Studies by FLAIG et al. (1978) revealed that the fertilizing effect of farmyard manure is better the finer it is spread, the higher the proportion of soluble N and the smaller the C/N ratio. The proportion of soluble nitrogen can be substantially improved through proper storage (MUSA

1975). Dung stored in deep pits contained six times as much nitrogen after 4 months as dung stored above ground (30 cm stack height), but the C/N ratio of 42:1 as opposed to 38:1 was greater (Table 7.8).

Table 7.8. Influence of stack height and storage duration on C/N ratio, moisture and the amount of soluble nitrogen in farmyard manure in the Sudan

Shape of pit (length x width x height)	C/N	ppm N N	 NO_3-N	 NH_4-N	Moisture (%)
Initial content					
1 m x 1.50 m x 30 cm	60	1.32	0.0	590	33.3
1m x 1.50 m x 1.50 m	62	1.36	0.0	590	33.1
After 4 months					
1 m x 1.50 m x 30 cm	38	1.26	47	260	17
1 m x 1.50 m x 1.50 m	42	1.48	64	1771	36

Source: MUSA (1975)

Table 7.9. Average contents of micronutrients in farmyard manure fertilizer (ppm in DM)

Micronutrient	SAUERLANDT and TIETJEN (1970) (Germany)	JAISWAL et al.(1971) (India)
Copper (Cu)	9.8	4.6
Zinc (Zn)	82.0	5.3
Manganese (Mn)	218.7	83.6
Boron (B)	17.4	0.1
Molybdenum (Mo)	0.7	no data
Cobalt (Ko)	1.0	no data

Besides the main nutrients, manure also contains a wide range of micronutrients. However, large differences in micronutrient contents may be observed, depending on soil and the diet of the animals (Table 7.9). Because the contents of trace elements in farmyard manure are primarily determined by the fodder, and the fodder by the site, any deficits of such nutrients cannot be alleviated with organic fertilizer alone. While availability is usually improved to some extent with organic fertilizers, a marked improvement will only be achieved when the nutrients that are lacking are introduced through better mineral nutrition of the animals or through additives (e.g. stone-meal).

Although conserving nutrients is a very important aspect of farmyard manure management, it is mistaken to regard farmyard manure as just a vehicle for nutrients. Manure is also an important source of humus and has a beneficial long-term effect on the structure and C-economy of the soil (see Section 7.6). Moreover, farmyard manure contains hormones, vitamins, and antibiotic and growth-regulating substances such as biotin, whose stimulating effect on root growth and on the growth of micro-organisms (yeast cultures) has been demonstrated experimentally (SAUERLANDT 1948; SAUERLANDT and TIETJEN 1970).

7.5 Spreading farmyard manure: techniques and quantity

Having obtained a good, nutrient-rich manure through careful collection, storage and transport, it is important to apply it to the fields in the most effective way. It should be spread carefully and evenly (no clumps), without disturbing the root area of the crops. This is easier to achieve with decomposed manure and manure composts than with fresh manure containing long straw. Once spread, manure should be worked into the soil as soon as possible, since long exposure on the soil surface causes a loss of nutrients and fertilizing effectiveness.

As Table 7.10 shows, nutrient losses are especially high in warm, sunny weather (SAUERLANDT 1948). According to studies carried out in Ohio, USA, 50% of the nitrogen was lost after 4 days of storage on the field (McCALLA 1975).

Table 7.10. Relative yields of fodder beets after applications of farmyard manure, as influenced by storage time of manure on the field

Incorporation after arrival on the field	Weather Overcast, rainy, no wind	 Sunny, clear, windy
Plowed in immediately	100	100
Plowed in after 6 hours	97	90
Plowed in after 24 hours	94	71
Plowed in after 4 days	86	58

Source: SAUERLANDT (1948)

Working the manure in close to the surface is better than burying it deep. The lighter a soil is, the deeper the manure can be incorporated (>20 cm). A highly decomposed or fermented manure can be plowed in deeper than a relatively fresh manure. The manure should be well mixed with the soil and no dense clumps should be left in the subsoil. A special form of manure application is as surface compost mulch. On heavy soils surface application of this kind can contribute to a physical improvement of the site by stimulating soil life (JAISWAL et al. 1971; KLAPP 1967). However the loss of nutrients with this method is high, and the nutrient effect becomes secondary to the mulching effect.[119]

There is some controversy as to how often and in what quantities farmyard manure should be applied. Whereas it was once assumed that small, frequent applications (4-8 t/ha) were more effective than heavier applications (150-250 t/ha) at longer intervals, opinion today is different. Twelve-year trials by GRIMES and CLARKE in Kenya (cited in WEBSTER and WILSON 1966) showed, for example, that the yields in a four-crop rotation receiving 6 t/ha of farmyard manure every year did not differ significantly from those obtained with 18 t/ha farmyard manure every 3 years.[120] Similar results are reported in Europe, where SAUERLANDT and TIETJEN (1970) showed that larger applications of fermented manure given every 3 years had a better humus effect (+0.2% in 12 years) and, with regard to humification, were therefore superior to other forms of application (fresh manure and/or yearly application). Results from Rwanda suggest that it is more effective to fertilize with farmyard manure at longer intervals than to treat all areas more frequently with small amounts (EGGER 1982). This is borne out by practices in the indigenous cropping systems of the Kofyar in Nigeria and the Wakara in Tanzania. They too apply farmyard manure or manure compost at longer intervals in their rotation, choosing crops that respond well to it (primarily *Pennisetum*). Usually a legume occupies a slot in the rotation between applications.

Applying manure at less frequent intervals also has advantages from a labor and organizational point of view. Covering large areas with small amounts requires more effort than covering small areas with large amounts.

The amount of manure applied should be determined by the effect sought. If the main aim is to make up for nutrient deficiencies, enough should be applied to achieve a rough nutrient balance. As experimental results show (see Section 7.6), even small amounts of farmyard manure (2.5 t/ha) are often sufficient to make a considerable impact on yields. This happens when a specific deficit (a single nutrient or micronutrient) is alleviated or when an important chemical, physical or biological property of the soil is changed.

If the humus level of a crop soil is to be increased, applications of 5-10 t/ha per year are necessary, according to trials in the West African savanna (JONES 1971). YOUNG (1976) regards applications of at least 10 t/ha per year as necessary if satisfactory yields are to be sustained over time on permanently cultivated Luvisols. Other authors recommend minimum applications of 5-9 t/ha (RODEL et al. 1980).

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[119] Surface compost mulch is only recommended on good soils well supplied with nutrients or for farms with large supplies of manure, and where the aim is to achieve soil physical improvements, for example in combination with sowing green manure.

[120] The question of how a soil utilizes different doses of stable manure naturally depends to a large degree on the soil itself. An active, well aerated soil, for instance, "digests" a larger application of stable manure with more ease and speed than a heavy soil.

Larger applications appear necessary in the permanently humid tropics (GODEFROY 1979), where at least 40-50% more is recommended (JAISWAL et al. 1971). They should be accompanied by measures to protect the soil (ground cover, etc)(AGBOOLA et al. 1975).

7.6 Effects of using farmyard manure

7.6.1 Experience and results from temperate regions

Extensive studies over long periods on the effects of farmyard manure are available from the temperate climate regions. As Table 7.11 shows, the humus content of soils is always improved by fertilizing with farmyard manure.

Apart from increased humus (between 15% and 50%, depending on soil and climate), increases in crumb stability and root permeability were observed. According to KLAPP (1967), the effect of farmyard manure in temperate climates extends to the improvement of all physical soil properties (crumbing, pore volume, water-holding capacity, water permeability, aeration, etc). Chemical-physical properties such as nutrient-holding capacity (sorption power) and the ability to release nutrients slowly (buffer capacity) are also improved.[121] Beneficial effects on soil life and the growth of roots and shoots have also been confirmed (e.g. FLAIG 1956).

Few long-term studies on the effects of farmyard manures have been carried out in tropical regions, particularly in the lowland tropics. From the few available data, however, it can be seen that farmyard manure has the same effects on the soil as in temperate climates (humification, nutrient effect, improvement of physical and chemical properties). In addition, some effects are more pronounced in the tropics, notably the alleviation of aluminum toxicity and the increased availability of phosphorus. The combined effect of mineral fertilizers and farmyard manure is also usually more marked in the tropics.

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[121] This is especially useful on poor, sandy soils.

Table 7.11. Changes in the C-content of topsoil in response to fertilizer

Location	Halle (FRG)	Askow (UK)	Askow (UK)	Lachstädt (FRG)	Bonn (FRG)
Length of trial (years)	80	50	50	52	52
Clay (%)	13	4	9	26	17
pH (KCl)	6.4	5.9	7.2	7.0	7.0
Farmyard manure (t/ha/year)	12.0	9.5	9.5	10.0	10.8
Treatments	-------- C-content (%) --------				
Not fertilized	1.14	0.79	1.30	1.49	1.12
P, K	-	-	-	1.48	-
N, P, K	1.26	0.96	1.43	1.61	1.18
Farmyard manure	1.69	1.09	1.52	1.77	1.21
N, P, K + farmyard manure	-	-	-	1.86	1.29

Source: Long-term field trials by several authors, cited in SCHEFFER and SCHACHTSCHABEL (1982)

7.6.2 Effect of farmyard manure on humus balance

The effect of farmyard manure on humus is evident in the tropics. On the ferrallitic loamy soils of Côte d'Ivoire, where bananas and pineapples are grown, applications of 10-50 t/ha of farmyard manure every 2 years produced an increase in C-content of 30-46% (GODEFROY 1979). AGBOOLA et al. (1975) reported that a moderate application of farmyard manure[122] on a crop soil in the rainforest zone was sufficient to slow down humus decomposition, which progressed only half as fast as with mineral fertilizers. On a savanna site at Samaru, Nigeria (1000 mm/year rainfall),

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[122] Unfortunately no exact figures are given - probably about 5-10 t/ha.

cropland (ferric Luvisols, sandy loam) had 50% and 90% more humus than the control plots after 15 years of applying 2.5 t/ha and 5 t/ha of farmyard manure per year. Relatively small doses had a marked effect, acting as a strong check on the decomposition of soil humus and other fertility-limiting soil properties (see Table 7.12, BACHE and HEATHCOTE 1969).

Table 7.12. Effects of 15 years of farmyard manure application on a crop soil (ferric Luvisol) at Samaru, Nigeria

Treatment Soil properties	No fertilizer (control)	2.5 t/ha farmyard manure/year	5.0 t/ha farmyard manure/year
C-content (%)	0.24	0.34	0.43
N-content (%)	0.021	0.028	0.034
CEC (m.e./100 g)	2.17	2.53	2.83
Exchangeable Ca (m.e./100 g)	0.73	0.92	1.14
Exchangeable Mg (m.e./100 g)	0.30	0.41	0.49
Exchangeable K (m.e./100 g)	0.14	0.17	0.19
pH (1:5 water)	5.4	5.6	5.8
pH (1:1 $CaCl_2$)	4.03	4.30	4.44

Source: BACHE and HEATHCOTE (1969)

As further trials on this site by JONES (1971) show, the yearly loss of humus in the control plot was still 3.5% even after 18 years of cropping. With farmyard manure (5 t/ha) the loss was greatly reduced, to around 0.7-0.8%. Applications of 12.5 t/ha of manure increased the humus. After 12 years of manuring, the humus content was nearly equal to that of a natural environment (1.5%). Similar results were achieved in long-term trials on red loams in Bihar, India (1400 mm/year). Here 20 t/ha of

farmyard manure applied over 20 years increased the C-content of a sandy loam from 0.6 to 1.1% (90% increase). As in temperate climates, the humus effect is strongly influenced by soils and site and only emerges clearly after many years of manure application.

7.6.3 Effect of farmyard manure on other soil properties

The sorption power - i.e. the soil's capacity to store and release nutrients - is also improved by manure application (Table 7.12). Impressive results in this area have been obtained by applying manure to wetland rice. Regular applications of farmyard manure (10 and 20 t/ha) over 27 years improved the cation exchange capacity (CEC) from 15 m.e./100g soil to 19 and 21 m.e./100g respectively (EGAWA 1975). Acidification is greatly reduced or reversed, the contents of exchangeable calcium and magnesium are increased, the contents of free aluminum and manganese can be reduced through regular applications, and root growth and the uptake of P are promoted (AGBOOLA et al. 1975; CHARREAU 1975).

In many experiments the amount of available iron found when farmyard manure was used was little different from that in minerally fertilized fields. Nevertheless, the danger of iron toxicity appears to be considerably less with manure. For example, AGBOOLA et al. (1975), working in West Africa, reported that iron toxicity could be reduced by applying decomposed organic fertilizer. MILLER and OHLROGGE (1958) demonstrated that the iron assimilation of maize and soybean fell substantially after applications of farmyard manure. They attributed this to the plants being less able to assimilate or transport large molecular compounds.

Physical soil properties such as water-holding capacity, erosion stability and gas exchange are also improved by applying farmyard manure. This means that after only a few years yield stability may be markedly higher than in fields where mineral fertilizers alone have been used. Thus in 5-year trials by RODEL et al. (1980) in Zimbabwe, the yield from fields fertilized with farmyard manure was higher in the dry year of 1967-68, with only 350 mm of rainfall, than in the previous year when 800 mm fell (see Table 7.13). In the next dry year, 1968-69, the differences were even more pronounced. As all trial plots had received a complete cover of green manure, this effect must be attributed to physical soil improvement. Moreover, it was observed that, compared with mineral N fertilizers, the effect with manure improved with each succeeding year (shown in bold in Table 7.13).

In trials by ABDULLAHI (cited in MOKWUNYE 1980), physical improvements in the soil appeared to be the reason why fields receiving 7.5 t/ha of farmyard manure for many years achieved higher yields than soils that had had large applications of mineral fertilizer but were undersupplied with organic matter (see Table 7.15).

Table 7.13. Effect of manures (from cattle corrals) and of mineral N fertilizer (KAS) on the maize yield (bags/ha) obtained from an acid, sandy loam in Zimbabwe[1]

Treatment[2]	Cropping season and year 1. 1964/65	 2. 1965/66	 3. 1966/67	 4. 1967/68	 5. 1968/69[4]	Mean
Control	2.9	9.4	3.9	8.5	0.5	5.0
4.5 t corral manure/ha (DM)[3]	2.2	14.0	9.1	26.0	2.7	10.9
9.0 t corral manure/ha	4.0	23.2	21.0	32.9	7.6	17.7
90 kg N/ha	10.4	53.9	48.4	34.6	8.9	31.2
180 kg N + 9 t corral manure/ha	26.0	79.0	80.5	48.9	37.5	54.4

[1] All treatments received green manure with P, K, Ca, Mg; the maize seed used was a high-yielding hybrid; [2] Only 5 out of 16 treatments given here; [3] Before being spread on the fields, 4.5 t dry weight of corral manure contained about 75 kg total N, 9.0 t 150 kg (ca. 1.7% N); [4] Extremely dry year.

Source: RODEL et al. (1980)

Many physical properties of soils (for example, infiltration capacity) can be more quickly improved with straw manuring (SOMANI and SAXENA 1975). Farmyard manure works more slowly, but as the length of time over which it is regularly applied increases, so does its long-term effectiveness.

As a final example of the physical effects of farmyard manure, results from an arid region of Tunisia (see Table 7.14) should be mentioned. Here, trials on the use of *Atriplex numularia*[123] to rehabilitate arid, saline soils showed that yield capacity was better promoted with small amounts of farmyard manure (3 t/ha) than with medium-size applications of a synthetic soil improvement agent (Agrosil S).

Table 7.14. Growth of *Atriplex numularia* (Oldman saltbush) under different soil treatments on a saline site in Tunisia

Treatment	Height cm	 %	Crown diameter cm	Biomass cm^3	 %
I. Control	16.2	100	7.2	122	100
II. Farmyard manure (3 t/ha)	39.2	242	17.4	712	563
III. Covered with plastic + Agrosil S (500 kg/ha) + K_2SO_4 (500 kg/ha)	32.9	203	13.3	514	421
IV. Agrosil S (1000 kg/ha)	48.6	300	28.2	1430	1172

Source: ROMMEL (1974)

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[123] Used as a pioneer and fodder plant on saline soils.

7.6.4 Effects of farmyard manure on nutrients and yields

The fertilizing effect, and especially the nitrogen effect, of farmyard manure usually lags behind that of corresponding amounts of soluble mineral fertilizers at first, because in the first growing period only part (30-60%) of the farmyard manure nitrogen becomes available.[124] The rest is fixed at first, or is serving to build up the soil's humus and nutrient supplies. The latter start to increase significantly with regular applications of farmyard manure (PRASAD and SINGH 1980). After two or three applications, both the immediate effect and the delayed effects of earlier applications coincide, and the manure starts to have its maximum impact on yields (JONES 1971).

Especially noticeable on tropical sites are the effect of manure as a P fertilizer and the improved effectiveness of mineral P fertilizers when combined with manure (MOKWUNYE 1980). AGBOOLA et al.(1975) describe a typical case of this: on an extremely acidic, humid tropical site, a mineral P fertilizer had no effect whatsoever on cowpea. But when the fertilizer was applied with relatively small amounts of farmyard manure (2.5 t/ha), increasing the amount of P applied also increased yields (see Figure 7.7).

A deficit of P or a decrease in its availability on cultivated soils can be counteracted by fertilizing with farmyard manure (GODEFROY 1979, PRASAD and SINGH 1980). The reasons why manure brings about an increase in available P are both chemical/physical in nature (higher pH, lower C/P ratio) and biological (heightened biological activity, increased mineralization of P compounds, increased root activity, etc).

OFORI (1980) suggests the following main reasons:

- Organic colloids prevent dissolved phosphate from coming into contact with free aluminum and iron,

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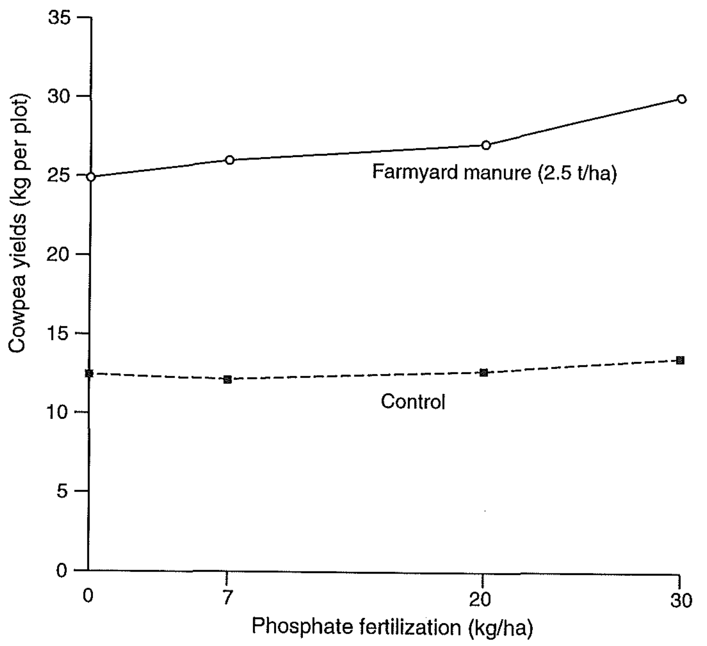
[124] Here too, exceptions confirm the rule. In Lushoto, Tanzania, higher maize yields were obtained with 10 t/ha of farmyard manure than with an equal application of N and P fertilizer (BAUM et al. 1983).

Figure 7.7. Yields of cowpea as affected by organic farmyard manure and phosphate fertilizer on an acid soil



Source: AGBOOLA et al. (1975)

- When organic matter decays, the carbonic acid that forms dissolves phosphate,
- Organic phosphorus is less strongly fixed by the soil, and
- Micro-organisms mineralize organic phosphate compounds.

The impact of farmyard manure on yields depends strongly on the site - that is, on the primary effect on soils (as N or P fertilizer, biological, physical) and on the state of the soil. On a dry savanna site in the Sudan, yields of sorghum were increased from 1.3 t/ha to 2.4 t/ha (i.e. by over 80%) by using just 4.0 t manure/ha (MUSA 1975). In contrast, 15.0 t/ha had little effect on a site in highland of Rwanda. The maize yield increased by only 30% to 1.3 t/ha. On a neighboring degraded site in the same country, the maize yield was increased from 0.6 to 1.3 t/ha. The effect here, with a rise of 116%, was very definite. Altogether, the results from Rwanda show that farmyard manure can positively affect yields in the second and sometimes even in the third subsequent cropping season (PIETROWICZ and NEUMANN 1987).

7.6.5 Residual effects

To assess the full effect of manure on yields it is vital that the delayed effects be taken into account - far more so than with mineral fertilizers.

Whereas in temperate climates the residual effects of fertilizing with farmyard manure last well into the third or even the fourth year (SAUERLANDT and TIETJEN 1970), in the tropics they will subside more quickly. Nevertheless, PEAT and BROWN (1962) detected residual effects up to 7 years after several years of manuring. The effect of farmyard manure alone was not enough to explain this long-term effect, since the manure had long since decomposed. Instead, a special, site-specific effect such as the amendment of a micronutrient deficiency was probably at work.

7.6.6 Effects of manuring in combination with mineral fertilizers

The complementary effect of farmyard manure and mineral fertilizers is known from temperate climates (DEBRUCK and von BOGUSLAWSKI 1979) and has also been confirmed in the tropics (RICHARDS 1967, ROCHE 1970, LAMARC 1972, GANRY et al. 1974, all cited in MOKWUNYE 1980). According to CHARREAU (1975), the combined effect of farmyard manure and mineral fertilizers is represented in Figure 7.8, in which higher yields are achieved with the same amount of nutrients when these are received in combined form (mineral and organic) than when mineral fertilizer alone is applied. This is especially true in the long term and when the level of mineral fertilizer is relatively low.

In Samaru, Nigeria, cultivated soil that had been inadequately supplied with nutrients for 20 years possessed a substantially lower yield capacity than soils receiving regular applications of farmyard manure. Even the largest doses of mineral fertilizer did not achieve the effect of moderate applications of farmyard manure and mineral fertilizers in combined form (Table 7.15). The synergistic effect of combined manure and P fertilizer, already mentioned in Section 7.6.4, was confirmed by the results from Samaru.

However, it was observed that adding one-sided nitrogen fertilizer to farmyard manure not only failed to promote the humus effect of the manure but actually reduced it by as much as 50% (JONES 1971; PRASAD and SINGH 1980).

Table 7.15. Maize yields (kg/ha) as affected by mineral fertilization after 20 years of treating the soil (ferric Luvisol) with varying yearly amounts of farmyard manure at Samaru, Nigeria

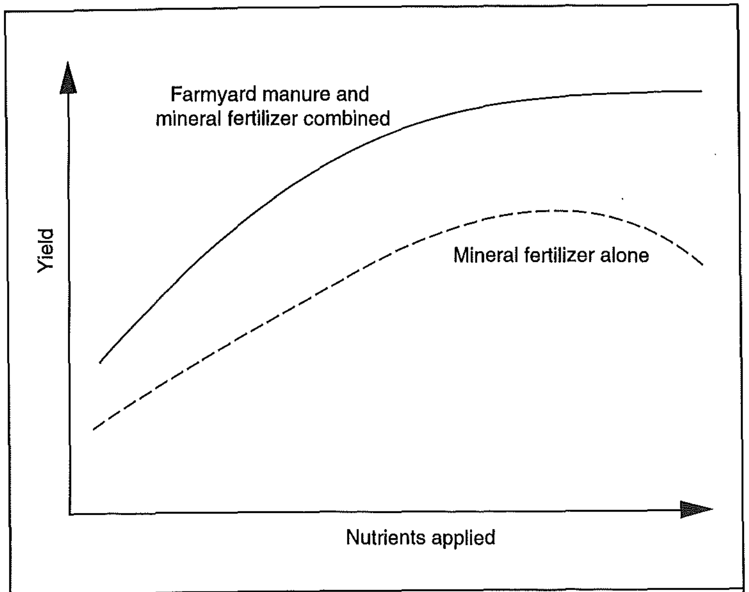
Treatment	Preceding long-term treatment (20 yrs) with farmyard manure (t/ha/year)			
N - P - K	O	2.5	7.5	12.5
0 - 0 - 0	33	584	2543	3145
134 - 28 - 56	1016	2316	3775	3821
268 - 56 - 112	2056	3311	4108	4247

Source: ABDULLAHI (1971), cited in MOKWUNYE (1980)

7.7 Socio-economic considerations

Despite the many positive aspects of manure application LENZNER and KEMPF (1982) and SCHLEICH (1983) point out that, even in areas where livestock production is traditional, it is often difficult to improve the care and conservation of manure. Manure heaps may not be tolerated in the farmyard on hygiene grounds. The handling of manure may be regarded as an inferior task. Farmers may be unwilling to devote labor to storing and applying manure. Where extensionists recommend subsidized mineral fertilizers, it becomes extremely difficult to promote the use of farmyard manure. In many areas, the shortage of firewood means that dung is dried and used as fuel for cooking, rather than being applied to crops.

Figure 7.8. Effect on yields of nutrients applied as (1) mineral fertilizer alone or (2) farmyard manure and mineral fertilizer combined



Source: CHARREAU (1975)

Where population pressure is high, increasing land scarcity and the curtailing or elimination of fallow periods are leading to declining soil fertility and to increased risk of erosion, forcing farmers to turn to some form of soil fertility management other than the fallow. As grazing areas shrink, stabling and fodder cropping become more attractive and farmyard manure assumes a more important role in the maintenance of soil fertility.[125]

This trend is already well advanced in heavily populated regions of Africa (especially at intermediate elevations) (NETTING 1968, LUDWIG 1967, EGGER 1982). However, because of their large labor requirement, ley farming systems in which fodder and food crops are rotated are usually out of the question for smallholdings dependent on hand hoeing rather than plowing. For these farms it is better to obtain fodder from permanent fodder plants or hedgerows. Such is the practice in Nyabisindu, Rwanda, where the fodder for cattle and goats comes from the grasses and bushes that make up anti-erosion belts. Because these only occupy 10% of the area, however, the amount of land required to grow enough fodder is still very high. According to KOTSCHI et al. (1991), 1.75 ha is required per cow (TLU) and 0.4 ha per goat. The authors therefore recommend semi-permanent stabling for cattle on larger farms, for example stabling overnight and grazing during the day. For farms of 0.5 ha or less they recommend that goats be kept in stables all the time. However, crop residues must then be used to supplement the fodder ration.

As DRESSLER (1983) found in Rwanda, raising cattle on farms of this size is impractical. Soil fertility is better maintained using a system of compost alternating with planted green manure fallows[126]

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[125] In Germany an increase in the production of manure was achieved only with the introduction of intensive indoor animal production systems, for which the cultivation of fodder plants became necessary. This was increasingly carried out on former fallows and pastures. As early as 1810, SCHÖNLEUTNER (cited in SAUERLANDT and TIETJEN, 1970) studied the conversion of crop rotations (fodder instead of fallow) and observed that fodder cropping had a positive effect on the amount of manure produced and hence on yields (+30-50%).

[126] This is based on the following assumptions: a) 20 t of compost/ha alternating with sown green manure fallows have the same impact on yields as 15 t of stable manure/ha, b) this is a subsistence-oriented farm with sufficient manpower.

Producing compost without using any animal dung whatsoever is difficult, if not impossible.[127] Raising small ruminants is a sensible solution because composting plant residues with their dung and perhaps a little earth is an easy way of producing a large amount of a good-quality organic manure. The Bontoc people of the Philippines keep one or two pigs and produce 25 t of compost per ha on their smallholdings (OMENGAN and SAJISE 1983).

The evolution from grazing to integrated crop-livestock production was observed in Nyabisindu, Rwanda, and is shown in Table 7.16.

Table 7.16. Steps in the integration of arable farming with livestock husbandry

Development level	Source of feed	Use of manure
Arable farm	Pasture	On crops only, incidental
	Pasture + supplementary feed from food cropping	Fertilization of the banana grove
	Pasture + supplementary feed from food cropping	Fertilization of annual and permanent crops
	Pasture + supplementary feed from food and fodder cropping	Specific manure production (stabling) + specific application to particular crops
Integrated crop and livestock production	Fodder cropping + supplementary feed from food cropping	Specific manure production (permanent or semi-permanent stabling) + specific application to particular crops

Source: LENZNER and KEMPF (1982)

Another important socio-economic consideration is the transportation of manure to the fields. As research by SCHLEICH (1983) in northern Côte d'Ivoire shows, considerable labor is involved in this; just how much depends on the distance to the fields and the kind of transport available (Table 7.17). Wherever possible, ox-carts or a similarly efficient means of transport should be used. Transport is the factor that most determines the economic viability of using farmyard manure.

Table 7.17. Labor (person-days) required for the use of dry manure* on 1 ha of cropland as affected means of transportation and distance of field from farm

Distance from farm (km)	------- Means of transporting manure -------			
	Night pen**	Ox-cart***	Bicycle/ moped	On foot
0.5	13.0	14.3	12.5	36.7
1	-	16.0	14.7	67.8
2	-	16.0	14.7	67.8
3	-	22.5	22.7	194.3

* 5 t DM manure; ** Traditional, portable, allowing direct manuring;
*** Labor required for loading and unloading, transporting and spreading manure on the fields.

Source: SCHLEICH (1983)

Because little time is available for transporting manure during planting, the dried dung or manure compost is often brought to the fields when there is a lull in work, i.e. during the dry season, 6-8 weeks before the beginning of the growing period (NETTING 1968). However, considerable losses may be incurred because the manure is left out on the field and it is impossible to work the manure into the soil immediately because of the dryness of the soil. More attention should therefore be given to the proper storage of manure on the fields. For example, large manure heaps

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[127] In a survey of farmers in Rwanda, all of those questioned felt that composting was only practical when combined with livestock production.

should be established and covered with straw and/or earth, as practised in China (KING 1911). This ensures that all the effort invested in the care of manure is not wasted in the last few weeks before planting.[128]

Regardless of whether manure is brought to the fields before or at planting time, a farmer will only use it if he or she derives some advantage from doing so. SCHLEICH (1983, 1985) cites two different situations in northern Côte d'Ivoire:

* Sufficient land is available to keep some fields fallow for many years. In this case, manuring competes with the option of cropping other fallow areas and therefore only makes sense when the benefit from applying manure is greater than the profit from clearing and planting additional land.[129] This was the case only when the manure was applied directly via the night pen (which was seldom possible), or when dried dung could be transported by ox-cart to fields within 1-2 km of the stables. It was assumed that 5 t of dry manure on maize brought an increased yield of 25-50% (see Figure 7.9, left hand side).
* Land is scarce. Fallow periods are too short and the soil is barely able to regenerate. In this situation, the returns to shifting cultivation decrease dramatically because yields decline, yet the labor required per hectare of maize (60-90 work days) remains the same or even increases (more frequent clearing for a single crop, increased weediness). Applying manure under these conditions brings the same increase in yields as can be achieved by cultivating an additional 0.5-1 ha of land. If the fields are not too far from the farm, it may even be worthwhile to transport the dry dung on foot (Figure 7.9, right hand side).

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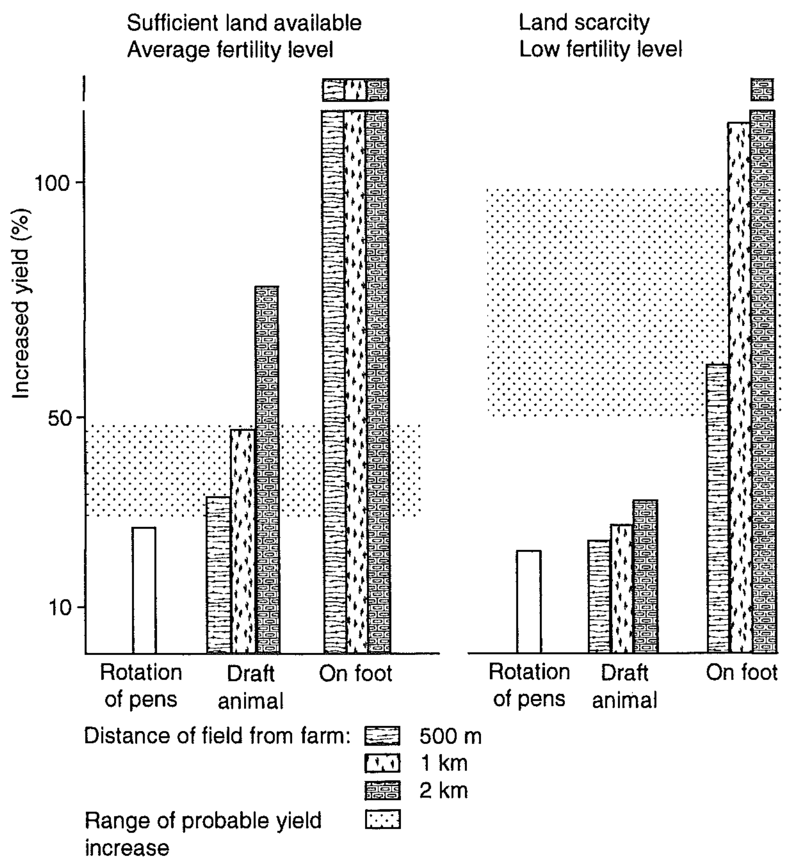
[128] Timely, low-cost interim transport and storage methods would help to solve the problem of the degradation of outlying land. This occurs when, through lack of time or transport, stable manure is used only on fields near the farmhouse. This restricts rotation design and land use, in that only relatively non-demanding crops can be grown on the impoverished outlying fields. If a way cannot be found of supplying these fields with manure, they must be more frequently planted with legumes or provided with green manuring.

[129] It should be noted that a field can be cropped longer when manured than under shifting cultivation without fertilizer. The relative amount of labor required for clearing land is thus less. This is especially evident when draft oxen are used, because if the field is to be plowed, clearing must be much more thorough than if cultivation is to be by hand, as in the latter case tree stumps are not a nuisance.

Figure 7.9. Viability of using farmyard manure measured in terms of the increased yield necessary to justify the cost of labor for transporting dry dung to the fields (Côte d'Ivoire)



Source: SCHLEICH (1985)

In concluding this discussion of socio-economic considerations, a few observations should be made concerning the advantages and disadvantages of solid dung as opposed to digested sludge and biogas. One of the indisputable advantages of fermenting animal dung in a biogas plant is that energy is recovered from the biomass and can be used again immediately. Fossil fuels, which are often very expensive, are thus conserved. The excessive deforestation that accompanies firewood shortages can be mitigated by the production of biogas.

But the high costs of building, maintaining and operating a biogas plant are serious obstacles to the spread of this technology in the smallholder sector. In India, for example, it was calculated that biogas plants were only economically viable with four cows or more, or if several smallholders cooperated (MAULIK 1982). Hence the collection and preparation of solid dung is usually better suited to small-scale subsistence-oriented agriculture.

An important question with regard to biogas plants is how the quality of sludge compares with that of farmyard manure. According to GARG et al. (cited in FAO 1981), sludge contains more organic matter and is less prone to nitrogen loss (Table 7.18). However, it is doubtful whether these advantages are really important in practice.

MAUEL (1984) cites numerous studies in which no significant difference could be found between the fertilizing effects of sludge and solid manure. ESGUERRA and STOCKER (no date) write that there is still great uncertainty as to the fertilization value of sludge. Only in the case of grassland fertilization do the results seem to favor sludge conclusively. In single-season fertilizer trials by GAEDE (1984), the yield of elephant grass following fertilization with sludge was much better than after a similar application of solid manure. On maize, however, farmyard manure (incorporated) was clearly superior, sludge (surface) producing almost no effect. The loss of nitrogen associated with this method of spreading is very high (soluble nitrogen is present in sludge almost exclusively in the form of ammonia). Considerable losses can also occur during long-term storage in expensive sludge tanks (WENZLAFF 1982).

Applying sludge to outlying fields presents even more of a problem with regard to transport and storage than does solid manure. Because sludge typically possesses only 2-5% dry matter and a nitrogen content of 0.14% (GAEDE 1984), huge amounts of liquid must be moved, a task which most smallholders are unable to undertake.

With its high moisture content, sludge is however well suited for compost preparation. JOGLEKAR (1982) suggests that its use as compost would be one way of improving the economic viability of biogas plants, which could be planned from the start to also function as composting plants. He reports outputs of 12.5 t of farmyard manure compost per cow per year, with a nitrogen content of 1.5%.

Table 7.18. Manure and gas production from 1 tonne of naturally moist cattle dung with 0.25% nitrogen

	Traditional manure production	Biogas fermentation
Loss of organic matter	500 kg	270 kg
Nitrogen loss	1.25 kg	Insignificant
Amount of fertilizer remaining	500 kg	730 kg
N-content of dry matter	1%	1.3%
Surplus		56 m^3 biogas*

* Average fuel value approx. 5000 kcal/m^3

Source: GARG et al., cited in FAO (1981)

7.8 Zonal aspects

In principle, fertilizing with farmyard manure is applicable in all zones where conditions are also favorable for raising livestock. In the tropics this includes the savannas and the highlands, where the incidence of animal diseases is generally lower (particularly tsetse-transmitted trypanosomiasis).

In the permanently humid tropics livestock husbandry is seldom practised extensively, so that it is usually not possible to obtain the quantities of manure required, which are in any case greater than in savanna areas. The use of farmyard manure in these zones therefore plays a minor role in comparison with other fertility promotion measures, such as intensive fallows and agroforestry.

The most positive results from the application of farmyard manure have been achieved in the savanna zones with a subhumid climate. Here even relatively modest applications of manure (5.0-7.5 t/ha) have often led to a substantial improvement in soil physical properties and the C and N status of the soils (JONES 1971, MOKWUNYE 1980).

In all zones, farmyard manure has proved extremely useful as a supplement to mineral fertilizers, whose effectiveness it was able to enhance considerably. Negative effects on soil properties resulting from the use of mineral fertilizers have been offset by using farmyard manure.

As with compost, storing manure in pits is preferable to stacking it above ground in dry areas. Deep farmyard manures may be regarded as advantageous in both subhumid areas and at higher elevations.

7.9 References

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