Animal draft tillage systems: the need for an integrated approach

by

Frank M Inns

Consultant Agricultural and Mechanical Engineer, 53 Alameda Road, Ampthill, Bedford MK45 2LA, UK

Abstract

The animal draft tillage system comprises the draft animal(s), the harness, the implement, the operator and the soil. In order to flourish the system must optimise its own inherent efficiency, it must compete with systems using alternative power sources and it must integrate beneficially with the agricultural production system and other systems within a broad national framework.

The animal draft tillage system has been brought to its present state by empirical development. Theoretical studies in draft animal ergonomics and animal/implement interaction are now needed to ensure further progress. Animal power is essentially complementary to human and engine power. Each farming operation has its own characteristics which will integrate best with a particular power source. Operational control of the power source by the farmer is of major importance in achieving timeliness in farming operations.

Integration of draft animal power into the national framework depends on farmer demand. Imposition of new implements and techniques is unlikely to succeed, however benevolent the intentions. Government policies often provide economic incentives which favour tractor power, making it difficult for draft animal power to compete on a fair basis.

Introduction

The animal draft tillage system has five essential components: the draft animal(s), the harness, the implement, the operator and the soil whose changed condition is the primary purpose of the system. The effectiveness of the system is often judged solely on its own internal performance, but a true assessment must also take account of its external relationships with the agricultural production system which it serves. Also, it must be judged within the prevailing social, industrial, economic and political factors at national and international levels. Figure 1 shows some of the factors which may interact with the animal draft tillage system, often exerting a strong influence on its viability.

The performance, and possible improvements, of animal draft tillage systems may conveniently be examined under three broad headings:

- performance in isolation from other systems
- performance in comparison with systems using other power sources
- performance as part of a wider system

Animal draft tillage systems in isolation

The best performance of any system depends upon the characteristics of each individual component and how the components interact. Interaction involves compromise in the interests of the system as a whole, not domination of the system by any particular component. For example, the performance of tillage implements, in terms of working depth and area rate of work, must be restricted to a level at which their draft requirement is matched to the sustained draft capability of the work animals.

Technological development generally proceeds through three phases. The first phase is empirical: advances in technology are achieved by trial and error combined with experience and shrewd insight. The second phase is theoretical: the experimental technology is reinforced by scientific (frequently mathematical) analysis, often involving idealised assumptions to simplify the theory. The third phase is one of accelerated practical development in which theoretical analysis facilitates rapid and significant improvements to technological practice.

Animal draft tillage systems are mainly at the first, empirical, phase of technological development. This phase, which has lasted some 5000 years, has led to some highly developed and technologically advanced systems, notably Indian and Pakistani tillage systems which use a traditional plow (*desi hal*). The second, theoretical, phase has unfortunately been diverted, by the introduction of tractors, to the analysis of tractor-powered systems. Equivalent attention to animal draft tillage systems would undoubtedly have led by now to a much better understanding of the technology, with consequential improvements. The theoretical phase is only now starting to make an impact.

Scientific studies into animal health, nutrition and work output are well advanced. They should be

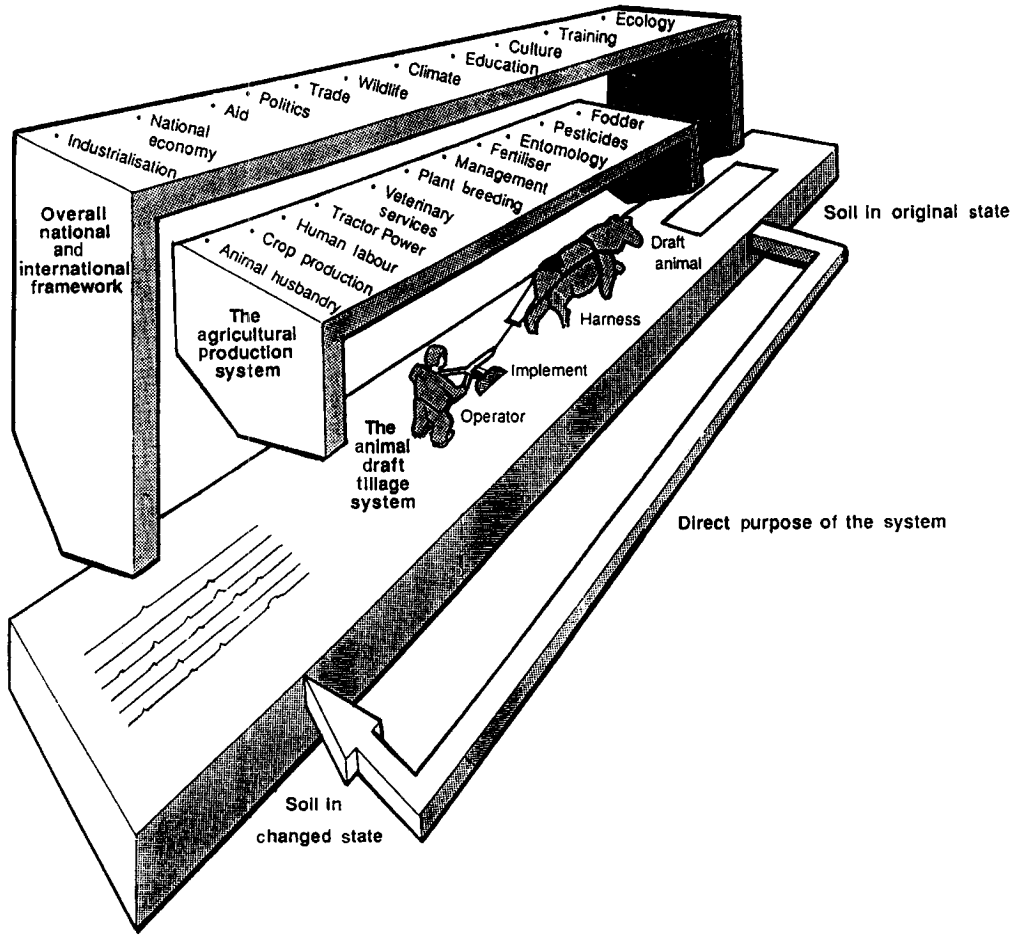

Figure. 1: The animal draft system, showing some factors which interact internally and externally

complemented by "draft animal ergonomics" as a new subject area which would include an investigation of muscular and skeletal interactions ("postural mechanics"?) as a contribution to harness design.

The theoretical study of soil/implement interactions is well established for tractor-pulled implements and the same principles are directly applicable to conventional animal draft implements.

Theoretical studies of animal/implement interactions have been made by Devnani (1981) and Inns (1990; 1991). These interactions influence the design and operational adjustment of both harnesses and implements, the development of which is still proceeding mainly on an empirical basis. These studies, together with theoretical studies in draft animal ergonomics, implement design and operator ergonomics, will provide a comprehensive basis for the accelerated practical development of draft animal technology, leading to the optimisation of animal draft systems.

Animal draft tillage systems and other power sources

In many areas draft animal systems have been long established, and their form and performance have changed little over many centuries. The introduction of tractor power during the past half century has upset this established equilibrium or near-equilibrium. Many of today's farmers have the freedom to choose between animal- or tractor-powered tillage systems, available under various ownership or hire arrangements, or to continue to use human-powered systems. Faced with this choice farmers will want to examine individual operations within the animal draft tillage system, to identify the most suitable power source for each.

The tillage system comprises operations aimed at land clearing and breaking, primary cultivation, seedbed preparation, ridging, sowing seed or transplanting seedlings and intercultivating for weed control and/or to improve soil condition by aeration, etc. Each operation has its own distinctive character. Some, such as land breaking and primary cultivation, demand high power inputs. Others, such as intercultivation for weed control, need less power but more skill and judgement in their application. Binswanger (1988) identified the "power intensive" operations as the first ones to be taken over by new, more powerful, sources of power when they became available, while the older power sources will continue to be used, advantageously, for "skill intensive" operations.

In these circumstances it is completely rational and valid for farmers to use tractor power, when available, for some, but not all, of their cultivation operations. The criteria of Binswanger (1988) can be used, with due caution, to identify those operations which are best suited to tractor power. Primary cultivation is the first of these while intercultivation for weeding would be among those less suitable for early tractor mechanisation. Current interest in single-animal working for weeding operations supports this proposition.

At the other end of the spectrum it will be unwise to promote the use of draft animal power for primary cultivation when tractor power is reliably available as an alternative. Operations which require teams of more than two animals would be particularly vulnerable to takeover by tractors. Efforts to develop big-team working are probably justified only in exceptional circumstances, and when tractor power is very uncompetitive.

For the individual farmer the move from animal power to tractor power is not solely a question of economic advantage. Smallholder farmers have very meagre (if any) cash reserves, so certainty in their cropping, and hence in the family's food supply, is of overwhelming importance. They are aware that prompt planting at the start of the rains generally leads to more reliable cropping and higher yields. The best guarantee of prompt action at critical times is given by operational control over power and machinery inputs, which is best achieved through ownership. For many farmers ownership of a draft animal team and implements is more desirable than tractor hire and more feasible than tractor ownership.

From the farmers' viewpoint the most profitable crop production system may well be one using a mixture of power sources—human, animal and engine. Each operation would be undertaken by the most suitable power source as judged by effectiveness, cost and operational control, to give an "integrated mechanisation" system having many advantages over the "comprehensive tractorisation" systems which attract the attention and support of many authorities.

Animal draft practitioners should be sensitive to both the advantages and the limitations of animal power applied to individual tillage operations, concentrating on those operations which offer significant technical, economic and operational benefits. The comparative advantage of animal-powered tillage operations will vary with locality, depending on the extent to which tractor power is available to the smallholder farmer. The comparative advantage is likely to be greater in those operations which require higher levels of skill and judgement.

Animal draft tillage systems in a broad context

The animal draft tillage system must be efficient in its own right, it must be competitive with tillage systems powered by other sources and it must interact with other systems—agricultural production, industrial, commercial, political, etc—to their mutual benefit.

Animal draft tillage systems cannot develop effectively in isolation from external influences. Because of the wide variety and complexity of the interactions involved there can be few common solutions. And because of constantly changing relationships there can be no definitive answer. A questioning, flexible and imaginative approach is a constant necessity.

Farmers should not be expected to change their agricultural production systems to suit draft animal technology. It is the animal draft tillage system which must serve the needs, including development, of the agricultural production system which is in use, not *vice versa*. According to Starkey (1988)

> ". . . research and development programmes should start with a humble approach and an understanding of local farming systems derived from discussion with farmers. Programmers should work closely with farmers and jointly identify and evaluate methods of improving farm productivity and incomes".

The successful introduction of new equipment is a consequence of demand by the farmer, not of a "solution" imposed from above.

Most developing countries have by now reached a stage where animal draft equipment can be manufactured locally, with consequent benefits to

the development of local artisanal and managerial skills. Experiences with local manufacture have been mixed. It has flourished in countries such as India, Pakistan and Thailand, where relatively small-scale manufacturers are in close contact with local farmers and respond to their expressed demands. In other countries, however, most of the factories set up by government or aid agencies to supply animal draft equipment have failed to operate profitably despite subsidised distribution and sale of the manufactured goods. Unsold stocks bear testimony to a failure to consult the farmers, primarily on what they want but also, to a lesser degree, on what they can afford. Production has been "supply led" rather than "demand led".

Commercial sector involvement with animal draft systems is weak in many countries. The import, manufacture, distribution and supply of animal draft equipment and replacement parts, and loans for the purchase of such equipment, are often undertaken by government and quasi-governmental agencies. In most cases farmers would be better served by commercial agencies, which respond more quickly and positively to their needs.

Political support for draft animal power is patchy. A number of countries have adopted a deliberate policy of concentrating attention on tractorised agriculture to the virtual exclusion of animal-powered systems. Even when priority promotion of draft animal power is an expressed policy, tractor power often receives disproportionate advantages, such as lower import duties, subsidised local production, subsidised fuel prices, acceptance and distribution of tractors through "aid" programmes and an emphasis on tractor power for government-run farms (military, prison and "commercial"). The work of research and testing institutions is often directed exclusively to tractor-powered equipment.

It may be difficult politically to smooth out economic and administrative distortions which interfere with power selection on a rational basis, but this must be done if a country is to benefit from a proper economic balance between alternative power sources on the farm. Sound progress in agricultural development depends upon a level playing field.

Conclusions

Within the animal draft tillage system attention should be given to building up a theoretical base in draft animal ergonomics and animal/implement interactions to accelerate improvements in harness design, which is seen as a critical factor in system efficiency.

Draft animal power, engine (tractor) power and human power should be seen as complementary power sources for agricultural production, not as mutually exclusive ones. The optimum mix will depend upon the requirements of each individual farming operation. It will vary from country to country and will change with time according to the viability of alternative power sources.

Farmers should have operational control over their power inputs if they are to start and complete farming operations on schedule. Ownership of draft animals gives a better opportunity for operational control than tractor hire.

The introduction of draft animal power in new areas, and of "improved" or new implements, should be a consequence of farmer demand, not a policy imposed from the top, however benevolent the intentions might be.

The relationships between farmers, manufacturers and commercial organisations should be allowed to develop symbiotically without undue interference.

Governments should provide a "level playing field" for human, animal and engine power through an even-handed approach to import duties, taxes, subsidies, "aid" programmes and support for research, development and extension.

Animal draft development activities should be pursued as integrated programmes, taking account of interactions with agricultural production, industrial, commercial, political, social and other relevant systems.

References

Binswanger H P, 1988. *Agricultural mechanization: a comparative historical perspective*,World Bank Working Paper 673, The World Bank, Washington DC, USA. 88p.

Devnani R S, 1981. *Design considerations for harnesses and yokes for draught animals.* Central Institute of Agricultural Engineering, Bhopal, India. 67p.

Inns F M, 1990. The mechanics of animal draught cultivation implements. Part 1. Chain-pulled implements. *The Agricultural Engineer* 45(1):13–17.

Inns F M, 1991. The mechanics of animal draught cultivation implements. Part 2. Beam-pulled implements. *The Agricultural Engineer* 46(1):18–21.

Starkey P, 1988. *Perfected yet rejected: animal-drawn wheeled tool carriers.* Vieweg for German Appropriate Technology Exchange, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany. 161p.